

Atlas of Reconstructive Breast Surgery

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Lee L.Q. Pu, MD, PhD, FACS, FICS

Professor of Plastic Surgery
Division of Plastic Surgery
University of California Davis Medical Center
Sacramento, CA, USA

Nolan S. Karp, MD, FACS

Professor of Plastic Surgery
Hansjörg Wyss Department of Plastic Surgery
NYU School of Medicine
New York, NY, USA

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Content Strategist: Belinda Kuhn
Content Development Specialist: Trinity Hutton
Project Manager: Anne Collett
Design: Patrick Ferguson
Illustration Manager: Paula Catalano
Marketing Manager: Claire McKenzie

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Foreword

Drs. Pu and Karp have put together a really comprehensive book that covers the full gamut of reconstructive breast surgery. The book is beautifully illustrated and comes with some excellent videos illustrating how these procedures are done. The layout of the chapters is consistent, first covering the information that everyone needs: indications, anatomy surgical technique etc. Each chapter has case examples that illustrate the points made in the first part of the chapter and is really a good way for the reader to get to understand the indications for each procedure. Most importantly, common complications are dealt with. This book

is a treasure trove for trainees but also for any established surgeon who includes breast reconstruction in their practice. Drs Pu and Karp are truly to be congratulated. They have gathered a who's who of breast reconstructive surgeons from around the world to contribute to this book and this is reflected in the quality of the chapters. From experience I know that this is not an easy task and is sometimes akin to herding cats. With this work the cats are truly in the pen.

Peter Neligan, MB, FRCS(I), FRCSC, FACS

Preface

Breast reconstruction is a common surgical procedure performed by many plastic surgeons around the world. It is an essential part of reconstructive breast surgery and good outcomes benefit many women with significant improvement in the quality of their lives after partial or total mastectomy for cancer. Many plastic surgeons, including both editors, started their careers by doing breast reconstruction and have gained extensive clinical experience over the years.

Although there are many published books on breast reconstruction, most books are either too extensive or not comprehensive enough. Because of the increased incidence of breast reconstructive surgery, many plastic surgeons have focused their clinical practice on this area. For this reason, there is a need to create an atlas of reconstructive breast surgery that is not too extensive, but comprehensive enough, to cover all contemporary breast reconstructive surgery.

In 2017 both editors were approached by a world-renowned medical publisher, Elsevier, to create an atlas of reconstructive breast surgery. We were asked to put together such an atlas that would be relatively handy and can be used worldwide by busy plastic surgeons for their daily practices in breast reconstruction. With these goals in mind, we have selected many international experts in breast reconstruction who have been at the forefront of breast reconstructive surgery. We have put together a 24-chapter atlas on reconstructive breast surgery that should be a good reference for most reconstructive breast surgeons.

In this atlas, we have eight chapters that focus on autologous breast reconstruction. Among these are chapters on free TRAM flaps, free muscle-sparing TRAM flaps, and DIEP flaps, the three primary work horses. In addition, advanced microsurgical breast reconstruction is presented including SIEA flaps, gluteal artery perforator flaps, profound artery perforator flaps, and transverse upper gracilis flaps. The traditional pedicled TRAM flap and latissimus dorsi flap are also included in this atlas. However, patient selection and the techniques for those traditional breast reconstructions have been updated. There are 6 chapters that focus on implant-based breast reconstructions. These

include chapters on one-stage immediate breast reconstruction, two-stage immediate breast reconstruction with ADM, and two-stage immediate breast reconstruction with total muscle coverage. A chapter on pre-pectoral implant breast reconstruction is also presented. As is a chapter on traditional two-staged delayed implant breast reconstruction. There is a chapter focusing on revision of implant-based breast reconstruction as well. Three chapters on partial breast reconstruction with flaps, local tissue rearrangement, and other breast surgical procedures are presented. Because symmetry is so essential in breast reconstruction, one chapter is devoted to describing the important symmetry procedures. Fat grafting for total breast reconstruction is an emerging procedure and included as a chapter as well. Fat grafting as an adjunct procedure in breast reconstruction is also included. There chapters on nipple/areolar complex reconstruction, an important part of breast reconstruction, and nipple sparing mastectomy, an increasingly popular procedure. The last two chapters contribute to correction of two of the most common congenital breast deformities: Poland syndrome and tuberous breast deformity.

Each chapter has a standard format and is relatively easy to read and follow. The chapters are well illustrated, with videos of some of the procedures provided.

We have tried our best to put together a comprehensive but concise atlas of reconstructive breast surgery. It would be an excellent reference book for plastic surgery trainees, young plastic surgeons in practice, or even senior plastic surgeons who just want to learn more contemporary techniques in breast reconstruction. It is our ultimate goal to provide an atlas that contains the most cutting-edge procedures in breast reconstruction and to improve overall outcomes of breast reconstruction. We sincerely hope that you would enjoy reading this atlas and find it useful in your busy clinical practice. We also hope that it would be able to benefit greatly to your patients.

Lee L.Q. Pu, MD, PhD, FACS, FICS
Nolan S. Karp, MD, FACS

List of Contributors

Olivia A. Abbate, BA

Georgetown University School of Medicine
Washington, DC, USA

Jasson Abraham, MD

Division of Plastic Surgery
Baylor Scott and White Hospital
Temple, TX, USA

Robert J. Allen Sr, MD

Director
Microsurgical Breast Reconstruction Department
Ochsner Baptist Hospital
New Orleans, LA, USA
Clinical Professor of Plastic Surgery
Plastic and Reconstructive Surgery Department
Louisiana State University
New Orleans, LA, USA

Peter Andrade, DO

Hackensack University Medical Center
Department of Plastic and Reconstructive Surgery
Hackensack, NJ, USA

Chad Bailey, MD

Plastic Surgery Chief Resident
Division of Plastic Surgery
University of California Davis Medical Center
Sacramento, CA, USA

Rudolf F. Buntic, MD

Fellowship Director
Plastic Surgery
The Buncke Clinic
San Francisco, CA, USA
Clinical Associate Professor (Affiliated) in Surgery
Stanford University Medical School
Palo Alto, CA, USA

Abhishek Chatterjee, MD, MBA

Assistant Professor of Surgery
Plastic Surgery
Tufts Medical Center
Boston, MA, USA

Mihye Choi, MD

Associate Professor
Hansjörg Wyss Department of Plastic Surgery
NYU Langone Health
New York, NY, USA

Oriana Cohen, MD

Fellow Physician
Hansjörg Wyss Department of Plastic Surgery
NYU Langone Health
New York, CA, USA

Alexandra Conde-Green, MD

Plastic Surgeon
Department of Plastic and Reconstructive Surgery
Hackensack University Medical Center
Hackensack, NJ, USA

Peter G. Cordeiro, MD

Chief
Plastic and Reconstructive Surgery
Memorial Sloan Kettering
New York, NY, USA
Professor of Surgery
Weil Medical College of Cornell University
New York, NY, USA

Emmanuel Delay, MD, PhD

Department of Plastic and Reconstructive Surgery
Centre Léon Bérard
Lyon, France

Kenneth L. Fan, MD

Resident Physician
Department of Plastic and Reconstructive Surgery
MedStar Georgetown University Hospital
Washington, DC, USA

Jordan D. Frey, MD

Fellow
Hansjörg Wyss Department of Plastic Surgery
NYU Langone Health
New York, NY, USA

Allen Gabriel, MD, FACS

Peacehealth Plastic Surgery
Peacehealth
Vancouver, WA, USA
Clinical Associate Professor
Department of Plastic Surgery
Loma Linda University Medical Center
Loma Linda, CA, USA

Juan Jose Gilbert Fernandez, MD

Aesthetic and Reconstructive Microvascular Surgeon
Precision Medical Arts of New York
Patchogue – Smithtown, NY, USA
Clinical Assistant Professor of Plastic Surgery
Louisiana State University
Department of Plastic and Reconstructive Surgery
New Orleans, LA, USA

Gabriele Giunta, MD

Resident
Division of Plastic and Reconstructive Surgery
Department of Surgical and Oncological Sciences
University of Palermo
Palermo, Italy
Clinical Fellow
Division of Plastic and Reconstructive Surgery
Department of Plastic and Reconstructive Surgery
University Hospital Brussels
Brussels, Belgium

Moustapha Hamdi, MD, PhD

Professor
Plastic and Reconstructive Surgery
Brussels University Hospital
Brussels, Belgium

Nolan S. Karp, MD, FACS

Professor of Plastic Surgery
Hansjörg Wyss Department of Plastic Surgery
NYU School of Medicine
New York, NY, USA

Kimberly Sophia Khouri, BS

Medical Student III
School of Medicine
New York University
New York City, NY, USA

Roger Khalil Khouri, MD, FACS

Medical Director
Miami Breast Center
Miami, FL, USA

Adam R. Kolker, MD, FACS

Associate Clinical Professor
Division of Plastic Surgery
Department of Surgery
Icahn School of Medicine at Mount Sinai
New York, NY, USA

Jennifer Lavie, MD

Division of Plastic and Reconstructive Surgery
Louisiana State University School of Medicine
New Orleans, LA, USA

Rachel Lentz, MD

Division of Plastic and Reconstructive Surgery
Department of Surgery
University of California, San Francisco
San Francisco, CA, USA

Joshua L. Levine, MD

New York Eye and Ear Infirmary of Mount Sinai Hospital
Department of Plastic and Reconstructive Surgery
Center for the Advancement of Breast Reconstruction
New York, NY, USA

Albert Losken, MD, FACS

Emory University
Division of Plastic and Reconstructive Surgery
Emory University Hospital
Atlanta, GA, USA

G. Patrick Maxwell, MD

Nashville, TN, USA

Andreea Carmen Meruta, MD

Department of Plastic and Reconstructive Surgery
Centre Léon Bérard
Lyon, France
Emergency Clinical Hospital of Plastic, Reconstructive
Surgery and Burns
Bucharest, Romania

Alexandre Mendonça Munhoz, MD, PhD

Coordinator, Breast Reconstruction Group
University of São Paulo School of Medicine
Chief, Breast Reconstruction Division
Instituto do Câncer do Estado de São Paulo
Assistant Professor, Breast Surgery Division
Hospital Sírio-Libanês
São Paulo, Brazil

Maurice Y. Nahabedian, MD

Professor
Department of Plastic Surgery
Virginia Commonwealth University – Inova Branch
Falls Church, VA, USA

Jonas A. Nelson, MD

Plastic and Reconstructive Surgery Service
Department of Surgery
Memorial Sloan Kettering Cancer Center
New York, NY, USA

Lee L.Q. Pu, MD, PhD, FACS, FICS

Professor of Plastic Surgery
Division of Plastic Surgery
University of California Davis Medical Center
Sacramento, CA, USA

Jessica F. Rose, DO

Microsurgery Fellow
Plastic Surgery
University of Pennsylvania
Philadelphia, PA, USA

David E. Sahar, MD, FACS

Associate Professor of Plastic Surgery
Division of Plastic Surgery
University of California, Davis
Sacramento, CA, USA

Michel Saint-Cyr, MD, FRCS

Professor
Plastic Surgery
Baylor Scott & White Health
Temple, TX, USA

Ara A. Salibian, MD

Resident Physician
Hansjörg Wyss Department of Plastic Surgery
NYU Langone Health
New York, NY, USA

Hani Sbitany, MD

Associate Professor of Surgery
Division of Plastic and Reconstructive Surgery
Department of Surgery
University of California, San Francisco
San Francisco, CA, USA

Paul L. Shay, MD

Division of Plastic Surgery
Department of Surgery
Icahn School of Medicine at Mount Sinai
New York, NY, USA

Torunn E. Sivesind, MD

PGY-1 Plastic and Reconstructive Surgery
LSU School of Medicine
New Orleans, LA

David H. Song, MD, MBA

Regional Chief
MedStar Health
Plastic & Reconstructive Surgery
Professor and Chairman
Department of Plastic Surgery
MedStar Georgetown University Hospital
Washington, DC, USA

Ping Song, MD

Plastic Surgery Resident
Division of Plastic Surgery
Department of Surgery
University of California Davis Medical Center
Sacramento, CA, USA

Hugo St Hilaire, MD, DDS, FACS

Section Chief
Associate Professor
Division of Plastic and Reconstructive Surgery
Louisiana State University School of Medicine
New Orleans, LA, USA

Liza C. Wu, MD, FACS

Associate Professor
Division of Plastic Surgery
University of Pennsylvania
Philadelphia, PA, USA

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My sincere appreciation also goes to all contributors of this atlas. Because of their clinical expertise, hard work, and desire to achieve excellency in reconstructive breast, we are able to put together such an atlas of reconstructive breast surgery. Without the contributions from those renowned experts, we would not be able to publish such a unique atlas in plastic surgery.

I wish to express my gratitude to Belinda Kuhn and her entire publishing team. Belinda is an incredible woman who can deliver unparalleled service in medical publishing. Under her leadership, this book project started with the table of contents, invitation to the contributors, editing and re-editing, until it has been well done. It has been a pleasure and a privilege to work with Belinda and her publishing team. They have ensured the best possible quality of each chapter and this atlas could not be successful without the effort and hard work by such an excellent team.

I have been very fortunate to hold a full-time academic position at the University of California Davis, in Sacramento, California. This renowned institution has superb faculty, staffs, and residents. Many of my former and current faculty associates have created an intellectually stimulating environment for me to write and edit such an atlas in plastic surgery. Many of my former and current faculty colleagues have helped me to cover my patients while I was concentrating on writing the chapters or away to go to the meetings. I would like to thank my current administrative assistant, Mrs. Delia Luna, who has provided me with tireless administrative support in preparation of manuscripts for the atlas.

Lastly, I wish to express my heartfelt gratitude to my wife, Yu-Shan (Emily), who has supported me for all these years of my academic career, and has kept everything in order at home so that I can concentrate on my work for this project in the late evenings and weekends, to my sons, Felix, Dustin, and Adrian, who have taught me the joy of

life outside of work, and my younger brother, Lijun (Leo), who has always encouraged me to take a difficult task. I also wish to express my gratitude and respect to my former professors and training program directors, Dr. Zhong-Gao Wang, Dr. James F. Symes, Dr. Marvin A. McMillan, and Dr. Thomas J. Krizek. With their inspiration and support, I have been able to successfully edit such an atlas in plastic surgery. In addition, I also wish to express my gratitude to my worldwide friends and colleagues in plastic surgery who have encouraged and supported me during this book project.

Lee L.Q. Pu

I would like to first thank Dr. Lee L.Q. Pu for seeing the need for an Atlas devoted exclusively to breast reconstruction. I appreciate the opportunity that he selected me to be his co-editor on this amazing project. It has been a pleasure for me to work with Dr. Pu on this book for the past three years. Dr. Pu is an internationally recognized plastic surgeon with multiple areas of expertise and experience. He is a true world traveler and educator who is invited to teach and lecture globally.

In addition, I would like to thank all of the contributors to this atlas. Each person is extremely busy both clinically and academically. I truly appreciate the time and effort put into writing and illustrating their chapters. These contributions have resulted in a truly unique resource that will hopefully be used worldwide to advance the field of breast reconstruction.

For the past 36 years, first as a house officer and later as faculty, I have been at NYU School of Medicine/ NYU Langone Medical Center. I have benefited from being trained and mentored by some of the real legends in surgery and plastic surgery. Their commitment to my education has allowed me to develop not only as a surgeon, but also as a person. I have had the honor to work with several generations of faculty, residents, and students who have and continue to teach me every day.

Lastly, I would like to thank my patients. Breast cancer diagnosis, treatment, and recovery is an extremely difficult process. The patients are the true heroes. Breast reconstruction can be the positive side of what is frequently a very challenging time. We help restore body image and dignity. I appreciate the opportunity to be my patients doctor and surgeon and to help them navigate this through this process.

Nolan S. Karp

Dedication

To my wife, Yu-Shan (Emily) and my children Felix, Dustin, and Adrian whose love, sacrifices, understanding, and unselfish support have made editing and writing this book possible.

To my parents and my younger brother who have supported me for all these years and have trusted me to pursue my dream to become an excellent academic surgeon through more than a decade's effort.

To my professors and teachers who inspired me throughout my surgical education to set up a higher standard in my career and to work harder to achieve it.

To my worldwide friends and colleagues in plastic surgery who have made so many remarkable contributions to our specialty and have consistently encouraged me to do the same.

Lee L.Q. Pu

To my wife, Joyce and my children Justin and Jenna whose love and unselfish support has made my academic and clinical work as a plastic surgeon possible for so many years.

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To my colleagues, residents, and students at NYU School of Medicine/ NYU Langone Medical Center who have taught me so much and have allowed me to develop as a person and as a doctor.

Nolan S. Karp

1

Breast Reconstruction With the Pedicled Transverse Rectus Abdominis Musculocutaneous (TRAM) Flap

CHAD M. BAILEY AND LEE L.Q. PU

► Introduction

Pedicled transverse rectus abdominis musculocutaneous (TRAM) breast reconstruction has been performed in patients for nearly four decades now. Many technical modifications have developed since Dr. Hartrampf's first operation, and these strategies have improved our ability to offer this operation to our patients while minimizing morbidity.

Plastic surgeons continue to perform pedicled TRAM flaps on a frequent basis.¹ The choice to perform a pedicled TRAM flap is typically multifactorial, contingent on the presence or absence of microsurgical expertise, capability, comfort with the procedure and, if applicable, the patient's desire to avoid or ability to tolerate a prolonged operation.²

The goal of autologous breast reconstruction is to reconstruct the breast with minimal morbidity while maximizing reconstructive result. In this chapter, the authors describe their preferred techniques for pedicled TRAM flap breast reconstruction, emphasizing several refinements so that a good outcome of the reconstruction with minimal abdominal donor-site morbidity can still be accomplished. In addition, patient selection, preoperative evaluation, management of complications, and secondary procedures are also described.

Indications and Contraindications

Unilateral pedicled TRAM flap breast reconstruction can be offered to patients with BMI <30 who desire autologous breast reconstruction and who have adequate lower abdominal adipose tissue and skin laxity, with a few anatomic contraindications. Ipsilateral Kocher or complete subcostal incisions disrupt the direct and collateral blood flow to the rectus abdominis muscle, and serve as absolute contraindications to pedicled TRAM breast reconstruction. Patients without those incisions and with adequate abdominal tissue who desire to avoid the risks associated with extended

operations can also be considered for pedicled TRAM breast reconstruction. Patients with low midline abdominal scars can still be considered for unilateral hemi-TRAM flap or bi-pedicled TRAM flap.³

Preoperative Evaluation and Special Considerations

Medically acceptable candidates for abdominally based autologous breast reconstruction must have adequate excess abdominal adipose tissue for reconstructed breast size and excess abdominal skin for primary closure of the donor site (Fig. 1.1). This is best determined by performing a pinch test with the patient in supine position with both knees moderately flexed. If the patient is large breasted, she should understand the inevitable need for symmetry procedure(s) to reduce the size of the contralateral breast as well as the possibility of requiring an implant in addition to the pedicled TRAM flap to achieve a symmetric result.

Abdominal scarring patterns must also be thoroughly considered and reviewed with the patient. As discussed above, a low midline abdominal scar does not prevent the use of a unilateral pedicled TRAM; however, the patient can be offered a hemi-TRAM flap, a bi-pedicled TRAM flap, or a hemi-TRAM flap with a unilateral free TRAM or deep inferior epigastric perforator (DIEP) flap to achieve adequate sized reconstruction.⁴

It is imperative to consider the patient's level of activity preoperatively. In considering pedicled TRAM reconstruction, it remains possible that physically active patients will have noticeable abdominal weakness, and could be more prone to develop bulging and hernias, though the evidence-based literature remains inconclusive on the topic.

Other important areas of consideration that will allow for adequate surgical planning are evaluation of rectus diastasis, typically best assessed on preoperative CT or MRI

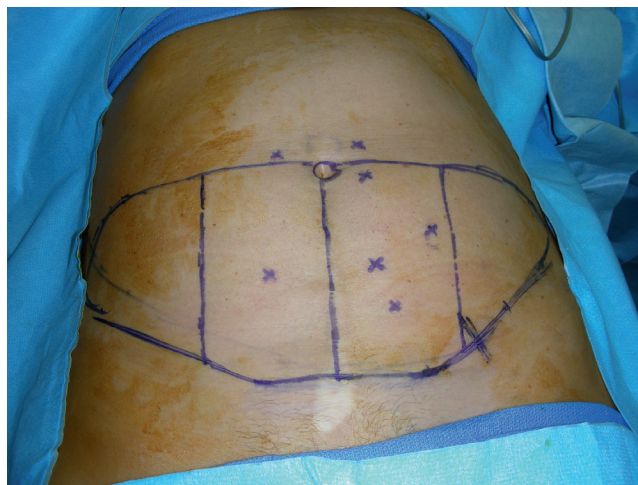


• **Fig. 1.1** A typical patient for the pedicled TRAM flap breast reconstruction. She has adequate lower abdominal tissue for a unilateral breast reconstruction.

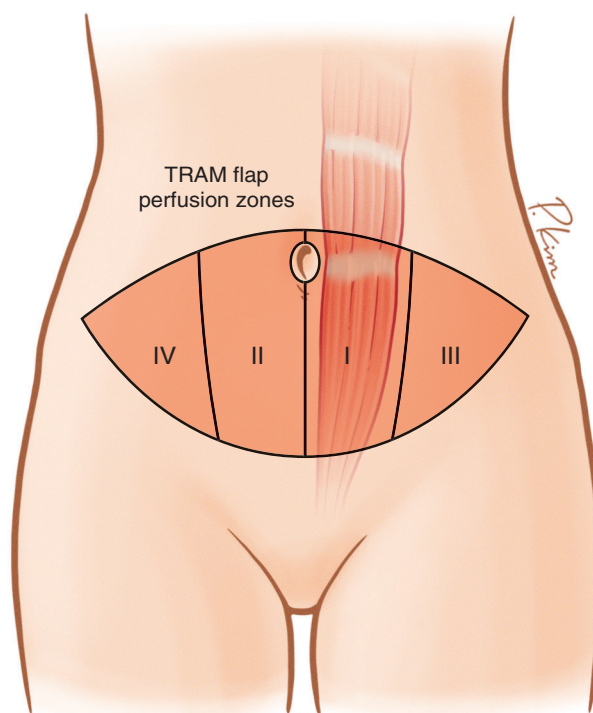
imaging; this can also be reasonably assessed while having the patient flex their trunk on the examination table and asking them to “lift your shoulders off the table.” Ventral and umbilical hernias, though difficult to detect in patients that have more abdominal tissue, must be screened for through physical examination.

Based on what we have learned to perform the free DIEP flap, the senior author prefers to evaluate the number of abdominal perforators and their locations and flow status immediately prior to the operation.⁵ This is done via duplex scanning in the preoperative holding area with both the vascular lab technician and the surgeon present to assist with preoperative marking. This has led to significant intraoperative time savings as well as increased confidence of side and perforator dominance, resulting in increased flap perfusion, decreased fat necrosis, and decreased need for the amount of rectus fascia that will be included with the flap dissection. In a unilateral pedicled TRAM flap for breast reconstruction, this allows the surgeon to select a better flap, based on the number of perforators and their locations and flow status, so a preferred side of the flap can be selected as the surgeon would do for a free DIEP flap (Fig. 1.2).

Due to the secondary and retrograde venous drainage provided by the superior epigastric vessels, pedicled TRAM flaps have indeed been associated with higher rates of fat necrosis, which is the rationale behind the Hartrampf zone classification⁶ (Fig. 1.3). In a unilateral reconstruction, this can be minimized by eliminating zone IV and portions of zone III. If a larger amount of flap tissue is needed for breast reconstruction or for smokers, a surgical delay procedure can be performed one to three weeks prior to the TRAM flap elevation so that its ischemic complications can be minimized.⁷



• **Fig. 1.2** Perforator anatomy as demonstrated by preoperative duplex scanning. In this patient, her left side has more prominent perforators and can be selected as the side for flap elevation.

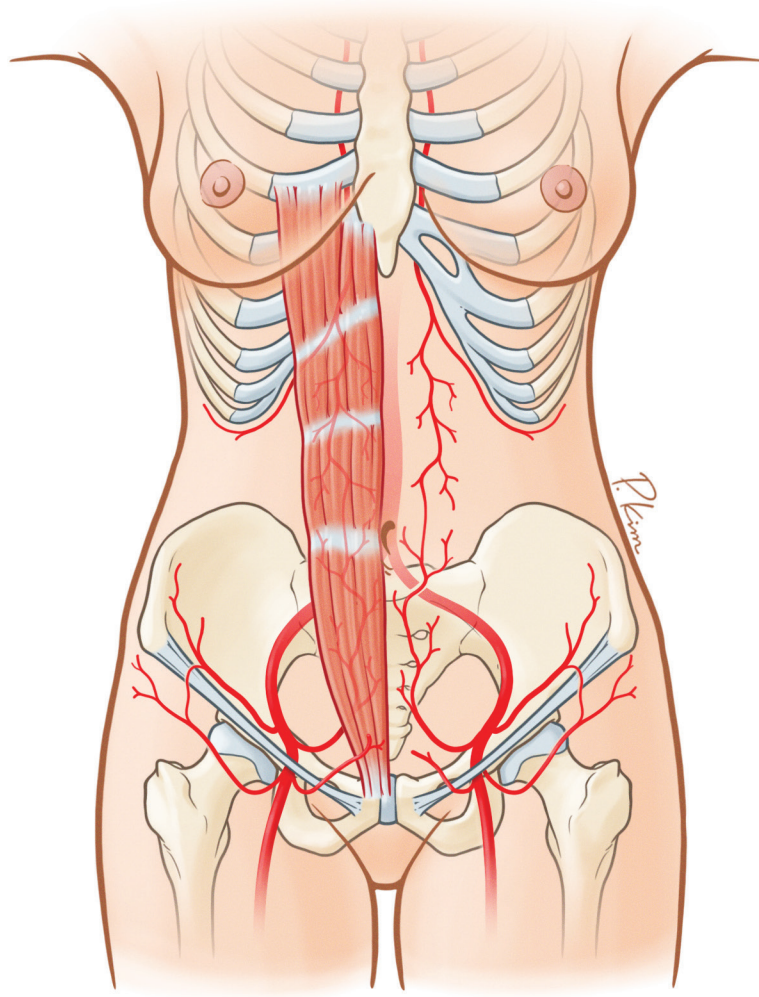


• **Fig. 1.3** A schematic diagram showing the Hartrampf zones of perfusion after elevation of the pedicled TRAM flap. Clearly, zone I has the best blood supply followed by zone II and zone III. Zone IV has the least adequate blood supply and may not be reliable.

Surgical Techniques

Relevant Anatomy

In the virgin abdomen, the dominant arterial inflow to one side of the abdominal skin is the deep inferior epigastric artery. In the majority of patients, there are three branching patterns that are relevant when performing perforator or



• **Fig. 1.4** A schematic diagram showing the dual blood supply to the rectus abdominis muscle. In a pedicled TRAM flap, the superior epigastric artery becomes a dominant pedicle after the inferior epigastric artery is divided during the flap elevation.

muscle-sparing (MS-)TRAM reconstructions. However, for the pedicled TRAM flap, the dominant arterial inflow is the superficial inferior epigastric artery (Fig. 1.4). Its venous outflow is accompanied to the artery and because the inferior epigastric vein is the dominant drainage system for the flap, it can be preserved to allow supplemental venous drainage for supercharge if needed.^{8,9}

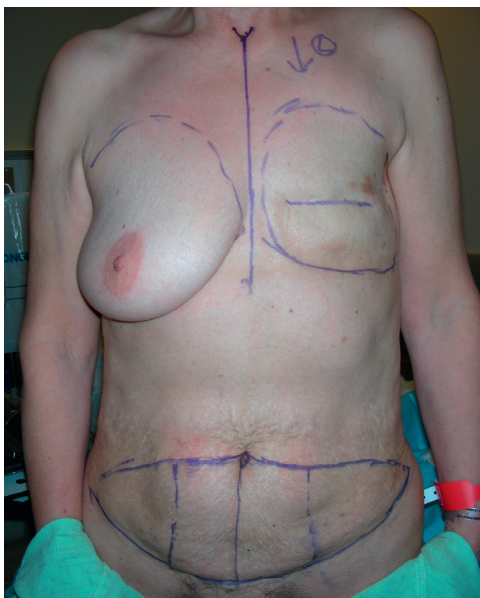
More relevant to the pedicled TRAM procedure are rectus inscriptions, which must be treated with meticulous technique as they run intimately across the epigastric artery arcade. Typically there exist three inscriptions, two of which will usually be encountered during the pedicled TRAM dissection. Should a pedicle vessel be injured, the flap may have enough collateral inflow to continue with the procedure based on the branching patterns previously referred to.¹⁰

It is imperative to be aware of and respect the arcuate line when harvesting the inferior aspect of the rectus muscle. Below the arcuate line (typically below the level of the iliac crests) there is no posterior rectus fascia. Imperfect

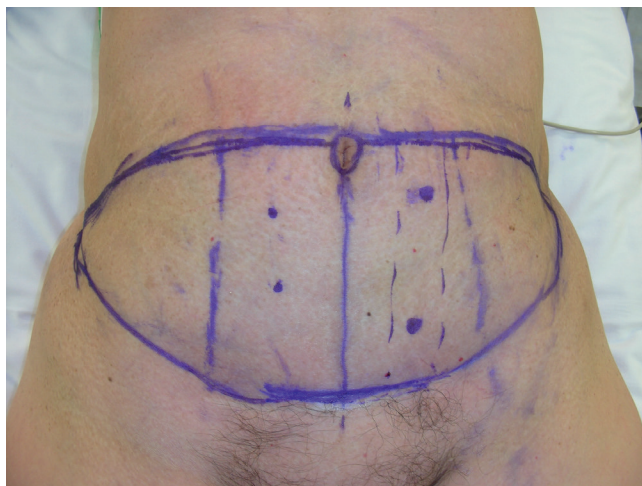
dissection posterior to the rectus muscle below the arcuate line can unnecessarily result in exposure of bowel contents and peritoneal fluid, causing additional strife and morbidity postoperatively.

Preoperative Markings

With the patient in standing position, the midline from umbilicus to pubic symphysis is marked. Next the inferior aspect of the flap is marked. The lateral extension of our inferior marking is frequently taken out into a natural skin crease but can be higher if we feel the need to move the flap superiorly. The superior aspect of the flap is then marked based on a pinch test in the lower abdomen with the understanding that this will be adjusted in the operating room (Fig. 1.5). The lateral border of the rectus abdominis muscle on each side is marked and based on the side of the selection for the flap and the location of perforators, the extent of fascial inclusion can also be marked (Fig. 1.6).



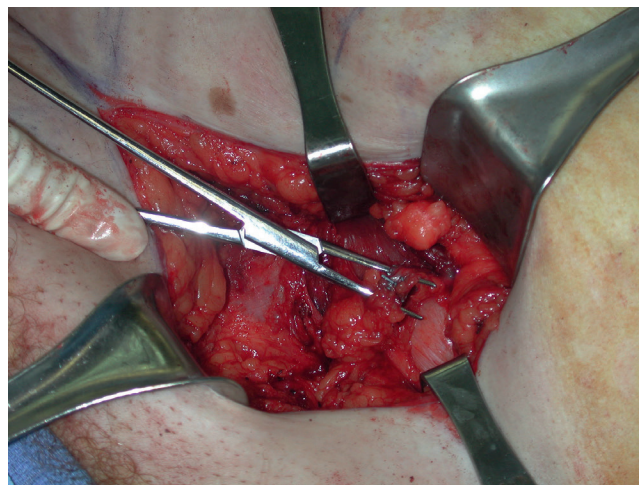
• **Fig. 1.5** An example of preoperative marking for a delayed breast reconstruction with a pedicled TRAM flap. The previous mastectomy site is also marked, and the breast skin pocket will be re-created.



• **Fig. 1.6** An example of preoperative marking for a unilateral pedicled TRAM flap breast reconstruction. The lateral border of the rectus abdominis muscle and the midline are marked. The amount of rectus fascia (outlined with the dashed line) that will be included with the flap is also marked based on the dominant perforator anatomy of the selected side.

Surgical Delay Prior to Flap Elevation

If the flap delay is indicated, the procedure can be performed under general anesthesia at a minimum of two weeks prior to the planned procedure to minimize the combined effects of two general anesthetics.^{7,11} It is imperative that all markings described above are made at the time of the initial procedure to ensure the incisions employed during the delay procedure can be incorporated during the flap elevation. The deep inferior epigastric vessels, after



• **Fig. 1.7** An intraoperative view showing the procedure of surgical flap delay. In this case, the inferior epigastric artery and vein are dissected free with the forceps and will then be divided with hemoclips.

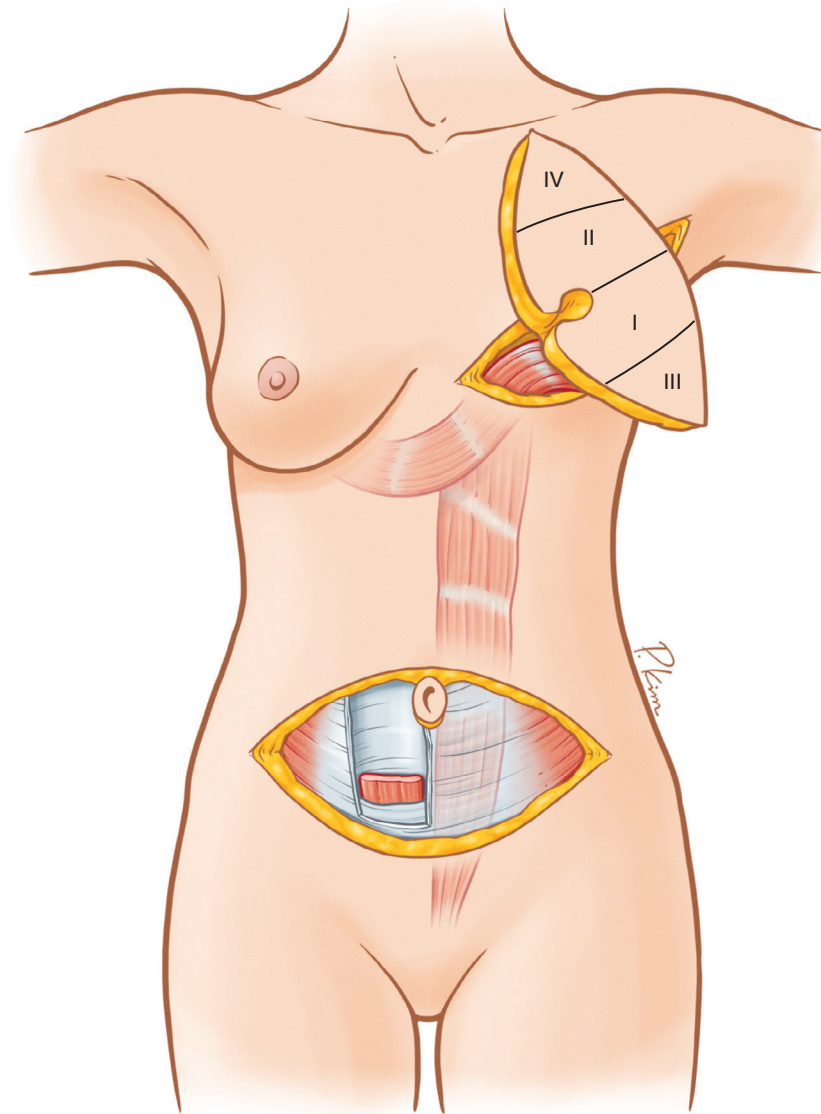
adequate exposure, are divided during the delay procedure (Fig. 1.7).

Flap Elevation

Unilateral

The umbilicus is first dissected free with preservation of adequate fat around it and down to the anterior rectus sheath. The TRAM flap skin paddle is then incised but beveled superiorly and inferiorly in the zone I and zone II areas to catch more flap tissue. Once the superficial inferior epigastric vessels are identified in each side, they are divided with hemoclips. From the non-flap side, the suprafascial dissection can be quickly done to about 1 cm beyond the midline. On the flap side, the suprafascial dissection is done towards the lateral border of the rectus abdominis muscle. The fascial incision is safely performed about 1–2 cm beyond the midline and about 2 cm medial to the lateral border of the rectus muscle. The dissection is taken down to elevate the entire rectus muscle in the lower part of the abdomen. During dissection, the inferior epigastric vessels under the muscle are identified and incorporated with the flap. The distal portion of the rectus abdominis muscle is then divided with protection of the inferior epigastric vessels. Once the muscle is divided inferiorly, the inferior epigastric artery and the vein are easily identified. The artery is divided with hemoclips but the vein is divided with hemoclips placed on the proximal end. The distal end of the vein is left open for temporary drainage throughout the case and will be clipped before the final flap inset.

The TRAM flap is then dissected free and elevated easily above the posterior rectus sheath. The superior epigastric vessels are identified within the deep surface of the flap and marked clearly with a marking pen. The superior abdominal skin is elevated to the xiphoid and an incision over the



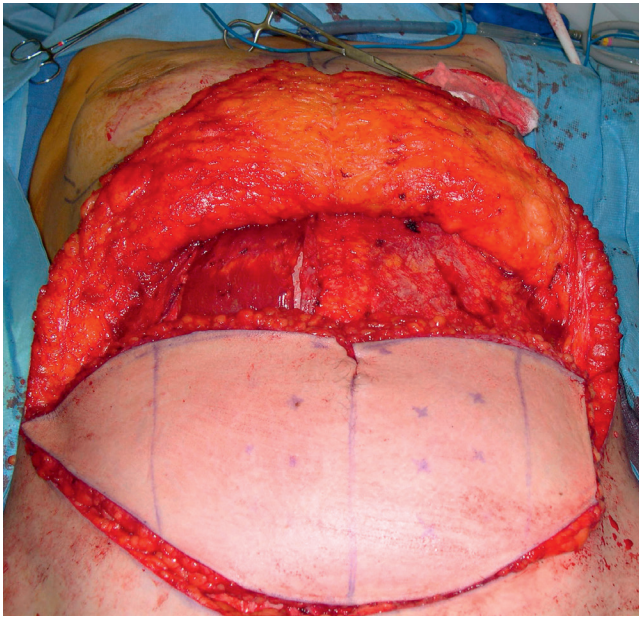
• **Fig. 1.8** A schematic diagram showing the TRAM flap inset. The flap can be tunneled contralaterally or ipsilaterally and orientated vertically or obliquely.

anterior rectus sheath is then extended to the level of the subcostal margin. All inscriptions in the superior part of the rectus muscle are dissected free and near the costal margin, the lateral part of the muscle is divided off the lateral costal margin to allow for more mobilization and a tension-free inset of the flap. A subcutaneous tunnel is made between the breast pocket and the upper abdomen (Fig. 1.8). The portion or entire zone IV of the flap is usually discarded before the flap tunneling (Fig. 1.9). The flap can be tunneled either ipsilaterally or contralaterally depending on the side of the flap selected. The tunnel should be wide enough, typically to pass through four fingers, to avoid any compression on the muscle within the tunnel. With the aid of lubricating jelly, the flap is passed through the tunnel and inset into the breast pocket. The pedicle should be checked for possible kinking and twisting and a few tacking sutures can be placed to secure the muscle so that

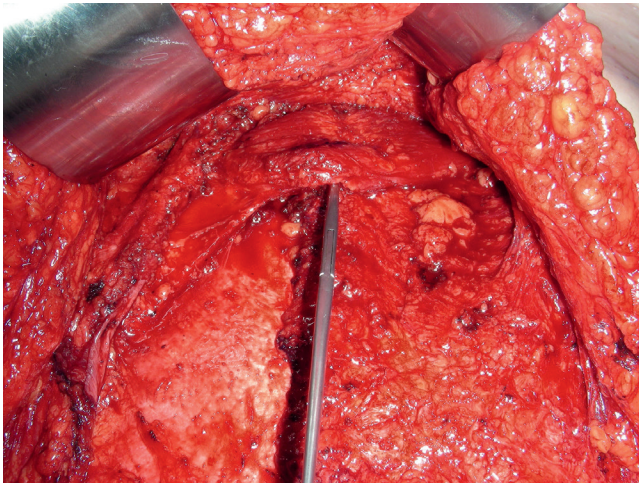
kinking and twisting of the pedicle can be further prevented (Fig. 1.10).

Bilateral

There are some differences when performing a bilateral pedicled TRAM flap compared to a unilateral procedure. The entire skin paddle of the lower abdomen is sectioned down the middle to allow for easier dissection from the midline to each medial side of the flap. We recommend midline sectioning following maximal lateral dissection, as this gives the surgeon perspective when trying to preserve specific perforators and save as much of the fascia as possible so that the size of its defect can be minimized. Once the deep inferior epigastric vessels are divided, the flap including the entire zones I and III from each side is elevated as the unilateral procedure but is tunneled ipsilaterally only (Fig. 1.11).



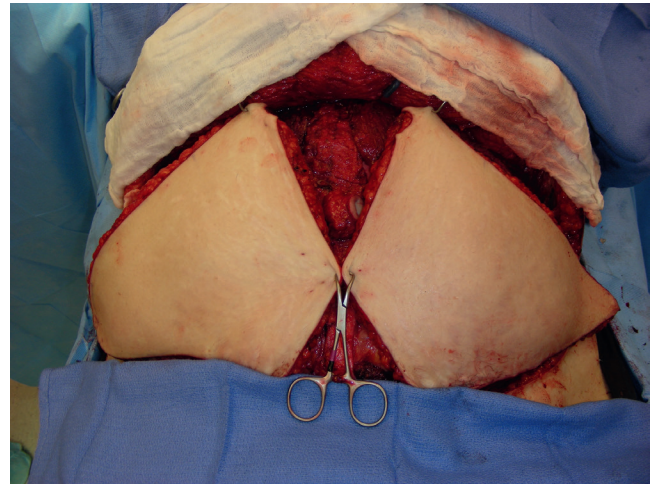
• **Fig. 1.9** An intraoperative view showing completion of the pedicled TRAM flap dissection. The portion or entire zone IV of the flap is discarded before the flap inset.



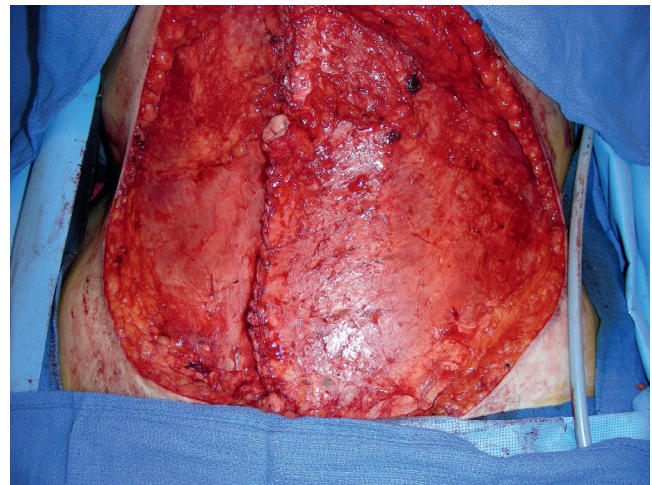
• **Fig. 1.10** An intraoperative view showing completion of tunneling for a unilateral pedicled TRAM flap after preliminary inset. The pedicle within the muscle (pointed out by a forceps) appears to remain patent without kinking or twisting.

Flap Inset

The flap is inset in an upright position. The inferior epigastric vein is clipped. Several 3-0 PDS sutures are performed to reconstruct the inframammary fold from inside the breast pocket. For unilateral TRAM flaps, the entire zone IV and part of zone III are usually discarded. For bilateral TRAM flaps, only a small portion of the zone III is discarded. The flap can be inset vertically or obliquely, and zone I should be placed in the center of the breast mound. Once the size and shape of the skin paddle are determined, the rest of the area is de-epithelialized. Additional excision of the flap



• **Fig. 1.11** An intraoperative view showing completion of the bilateral pedicled TRAM flaps. For each side, both zone I and zone III of the flap are needed for the flap inset.

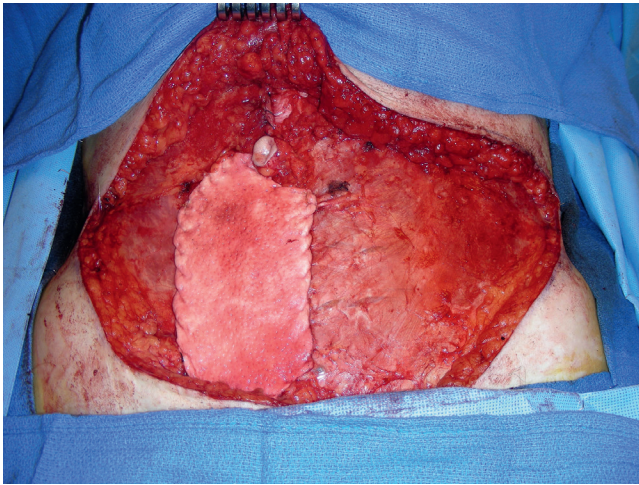


• **Fig. 1.12** An intraoperative view showing completion of the donor site closure after elevation of the pedicled TRAM flap. Since only a relatively small portion of the rectus fascia is harvested with the flap, the fascial defect can be closed primarily without difficulty.

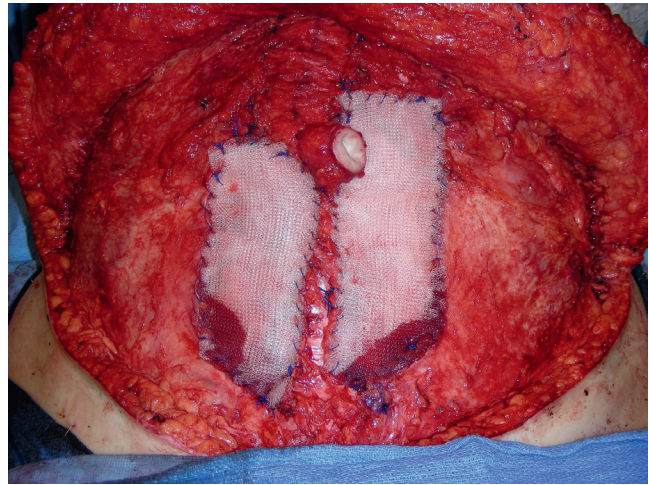
tissue can be done as needed to tailor the size and shape of the reconstructed breast. One or two drains are placed within the breast pocket under the flap. The final flap closure is then performed in two layers.

Abdominal Closure

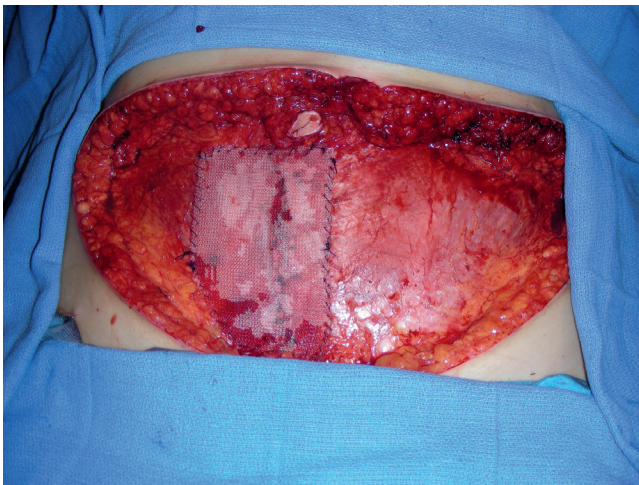
For unilateral TRAM flap donor sites, the entire length of the anterior rectus sheath is closed primarily with 2-0 Prolene suture in an interrupted figure-of-eight fashion to reduce the tension on the fascial closure followed by a 1-0 Prolene suture in a simple running fashion (Fig. 1.12). In the senior author's practice, a lower part of the fascial defect can be approximated without problem. However, a biological mesh (Fig. 1.13) or synthetic mesh (Fig. 1.14) is routinely placed as an onlay graft with 2-0 PDS sutures to reinforce lower abdominal fascial closure.



• **Fig. 1.13** An intraoperative view showing placement of an onlay biological mesh over the lower abdominal TRAM flap donor site for additional reinforcement after primary closure of the fascial defect.



• **Fig. 1.15** An intraoperative view showing placement of an inlay synthetic mesh for primary closure of the fascial defect over each abdominal donor site in a bilateral TRAM flap breast reconstruction patient.



• **Fig. 1.14** An intraoperative view showing placement of an onlay synthetic mesh over the lower abdominal TRAM flap donor site for further reinforcement after primary closure of the fascial defect.

For bilateral TRAM flap donor sites, the upper anterior rectus sheath can be closed primarily in the same way as for the closure of unilateral TRAM flap fascial defect. For the lower part of the fascial defect in each flap donor site, an inlay synthetic mesh is placed routinely to close the lower abdominal fascial defect. Because of relatively small fascial defect on each side, a large amount of inlay mesh can be avoided ([Fig. 1.15](#)).

The abdominal skin defect is closed as the same as abdominoplasty. More undermining of the superior abdominal skin flap can be performed as needed so that the skin defect can be accomplished with less tension. The umbilicus is brought out through the midline at the level of the superior iliac spine and inset through the skin and closed in two layers. The final abdominal skin closure is then performed in three layers (Scarpa's fascia, deep dermal, and skin) accordingly after placement of two drains under the lower abdominal skin flap.

Case Examples

CASE 1.1

A 53-year-old white woman had previous left mastectomy for breast cancer about 10 months ago and desired abdominally based autologous breast reconstruction ([Case 1.1.1](#)). She underwent a contralateral pedicled TRAM flap for her left breast reconstruction ([Case 1.1.2](#)). [Case 1.1.3](#) shows the immediate result after her left breast reconstruction. The abdominal fascial defect was closed primarily but also reinforced with Prolene mesh in an onlay fashion. [Case 1.1.4](#)

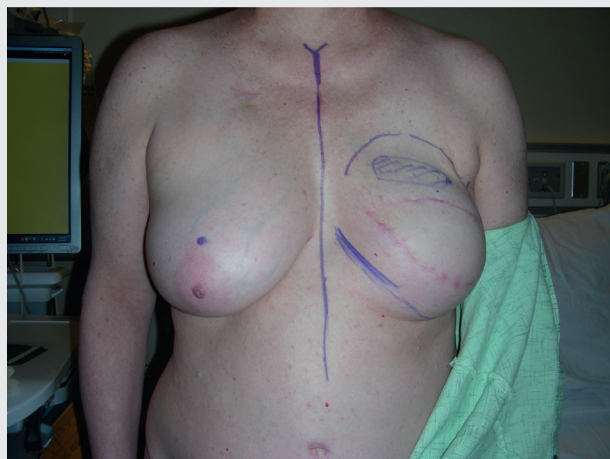
shows the result at 5 months, right before the revision of left reconstructed breast and right mastopexy for symmetry (second-stage reconstruction). [Case 1.1.5](#) shows the result at 4 months after her second-stage reconstruction right before the nipple/areola reconstruction. All her postoperative courses were uneventful. [Case 1.1.6](#) shows the result at 5 months after her nipple reconstruction, 9 months after second-stage reconstruction and 13 months after initial breast reconstruction.

Continued

CASE 1.1—cont'd



• Case 1.1.1



• Case 1.1.4



• Case 1.1.2



• Case 1.1.5



• Case 1.1.3

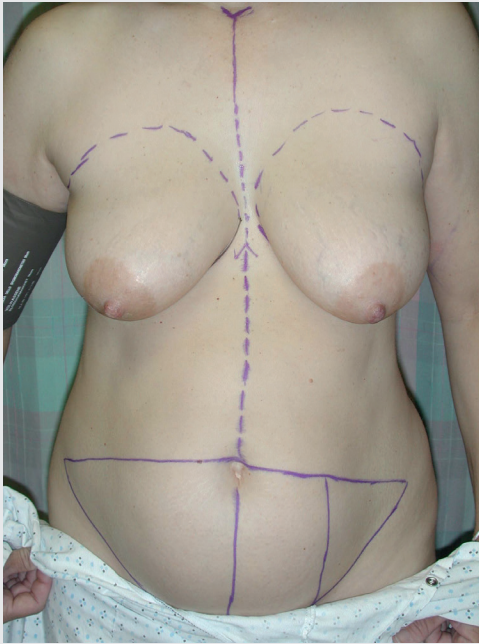


• Case 1.1.6

CASE 1.2

A 46-year-old white woman underwent right skin-sparing mastectomy for breast cancer and desired abdominally based autologous breast reconstruction ([Case 1.2.1](#)). She underwent immediate right breast reconstruction with a contralateral pedicled TRAM flap ([Case 1.2.2](#)). [Case 1.2.3](#) shows the immediate result after her right breast reconstruction. The abdominal fascial defect was closed primarily. [Case 1.2.4](#) shows the result at 10 weeks right before the revision of right reconstructed breast and left mastopexy for symmetry

(second-stage reconstruction) and [Case 1.2.5](#) shows the immediate result after the above procedures. [Case 1.2.6](#) shows the result at 5 months after her second-stage reconstruction right before the nipple/areola reconstruction and [Case 1.2.7](#) shows the immediate result after her nipple reconstruction. All her postoperative courses were uneventful. The result is shown at 18 months after initial breast reconstruction ([Case 1.2.8](#)).



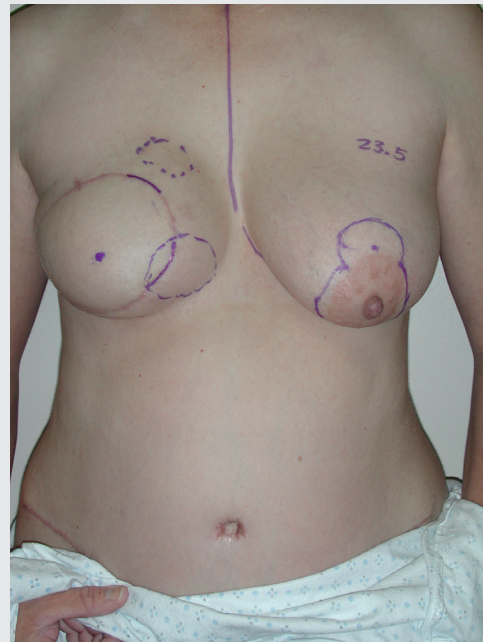
• Case 1.2.1



• Case 1.2.3



• Case 1.2.2



• Case 1.2.4

CASE 1.2—cont'd



• Case 1.2.5



• Case 1.2.7



• Case 1.2.6



• Case 1.2.8

CASE 1.3

A 44-year-old white woman underwent bilateral skin-sparing mastectomies for right breast cancer and desired abdominally based bilateral autologous breast reconstructions ([Case 1.3.1](#)). She underwent immediate bilateral breast reconstructions with two ipsilateral pedicled TRAM flaps ([Case 1.3.2](#)). [Case 1.3.3](#) shows the immediate result after her bilateral breast reconstructions. Each side of the abdominal fascial defect was closed primarily with Prolene mesh in an inlay fashion. [Case](#)

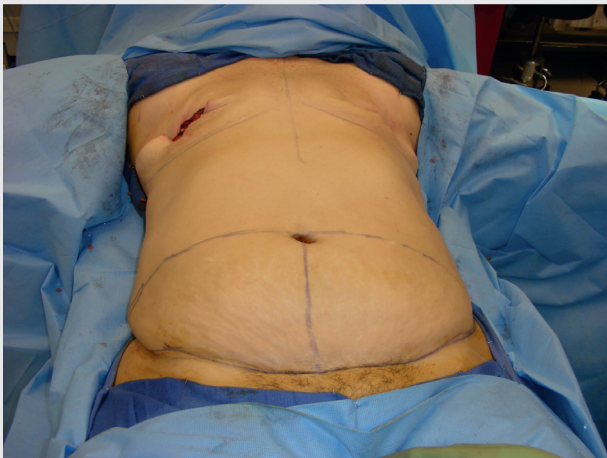
[1.3.4](#) shows the result at 8 months after initial breast reconstruction. She subsequently underwent bilateral nipple/areola reconstructions and revision of right reconstructive breast including fat grafting and the immediate result is shown in [Case 1.3.5](#). All her postoperative courses were uneventful. [Case 1.3.6](#) shows the result at 8 months after her nipple reconstruction and 18 months after initial breast reconstruction.



• Case 1.3.1



• Case 1.3.4



• Case 1.3.2



• Case 1.3.5



• Case 1.3.3



• Case 1.3.6

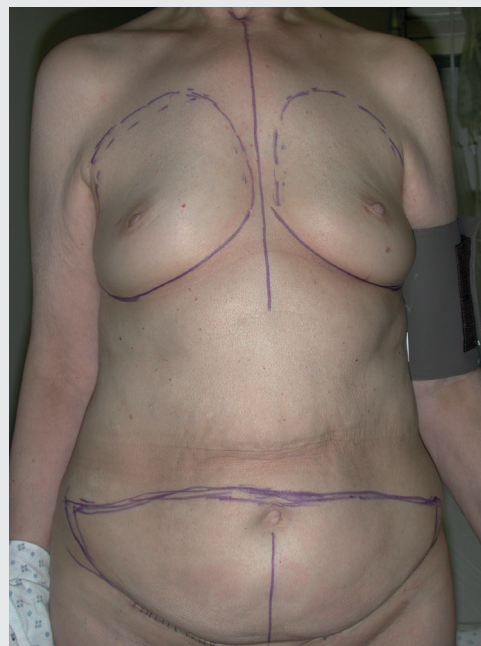
CASE 1.4

A 63-year-old white woman underwent prophylactic bilateral skin-sparing mastectomy and desired abdominally based bilateral autologous breast reconstructions ([Case 1.4.1](#)). Because she was a smoker, the surgical flap delay was performed for each side 2 weeks before bilateral mastectomies ([Case 1.4.2](#)). She underwent immediate bilateral breast reconstructions with two ipsilateral pedicled TRAM flaps ([Case 1.4.3](#)). Each side of the abdominal fascial defect was repaired

with Prolene mesh in an inlay fashion. The immediate result after her bilateral breast reconstructions is shown in [Case 1.4.4](#). She subsequently underwent bilateral nipple/areola reconstructions and the result at 6 months after her nipple reconstruction is shown in [Case 1.4.5](#). All her postoperative courses were uneventful. The result is shown at 6 months after her nipple reconstruction and 15 months after initial breast reconstruction ([Case 1.4.6](#)).



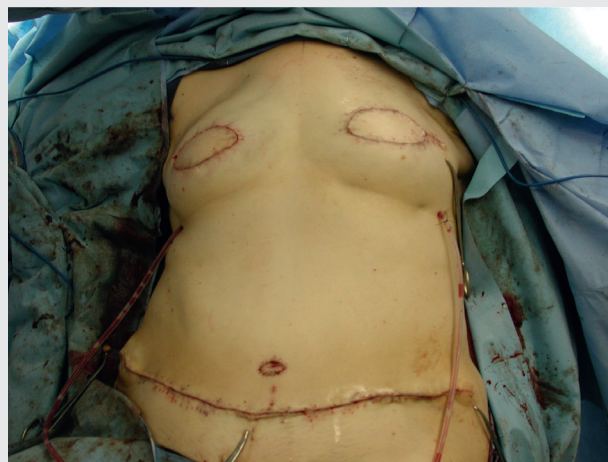
• Case 1.4.1



• Case 1.4.3



• Case 1.4.2



• Case 1.4.4

CASE 1.4—cont'd



• Case 1.4.5



• Case 1.4.6

Postoperative Care and Expected Outcomes

Postoperative care for pedicled TRAM flap breast reconstruction is similar to care following a major flap reconstruction. The patient is kept warm and well hydrated with good pain control. The flap is monitored clinically, and an abdominal binder is placed for support. The patient is encouraged to ambulate earlier. Once the patient tolerates oral intake and pain control is adequate with oral medications, she can be discharged home. In general, a 3- to 5-day hospital stay is needed depending on the speed of the patient's recovery. Drains are removed when the output is < 30 cc/day for 2 consecutive days during follow-up. Activity is limited to lifting of no more than 5 lbs (2.25 kg) for 6 weeks postoperatively and the patient can resume all her normal activities after 6 weeks.

Good to excellent breast reconstruction can be achieved if there are no surgical complications related to the flap or abdominal donor site. Primary healing can be expected in 3 weeks and the patient should feel normal after close to 6 weeks of recovery. Complications such as partial flap loss, flap fat necrosis and abdominal wound healing problems may occur and should be managed properly. In addition, flap contour deformity, symmetry issues related to the contralateral breast, or bulging in the abdominal donor site can be managed through re-operations.

Management of Complications

Partial flap loss can be managed with superficial debridement or more extensive excision of necrotic flap tissue. If a significant portion of flap tissue will be removed (Fig. 1.16A), a pedicled latissimus dorsi musculocutaneous flap can be performed as a salvage procedure for breast reconstruction (Fig. 1.16B).

Fat necrosis can be a common problem for a pedicled TRAM flap breast reconstruction.² If fat necrosis is localized and palpable, direct excision is our preferred method during revision surgery for the reconstructed breast. If contour deformity after excision of fat necrosis becomes obvious, fat grafting or reshaping of the breast skin envelope can be performed.

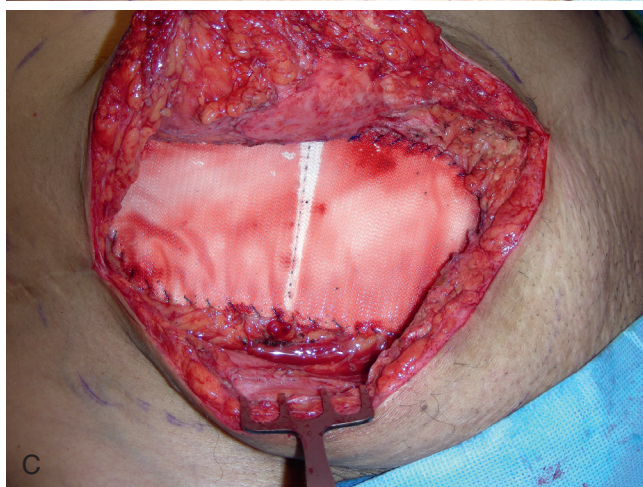
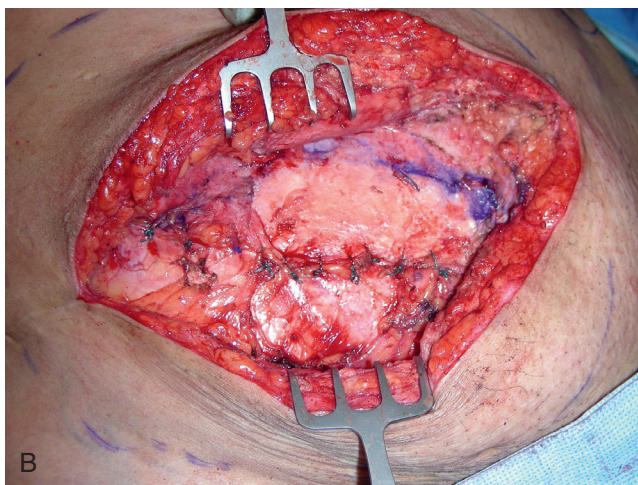
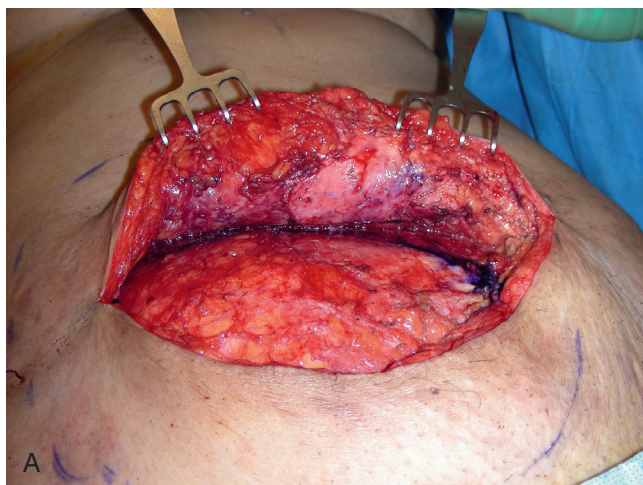
Abdominal skin flap necrosis can cause delayed wound healing in some patients and can be managed with adequate debridement and local wound care. If the size of skin flap necrosis is more extensive, vacuum-assisted closure (VAC) can play a role after proper wound debridement. In general, a skin graft is rarely needed for the above condition.

Secondary Procedures

For unilateral pedicled TRAM flap breast reconstruction, mastopexy or breast reduction is often needed for the contralateral "normal" breast as a symmetry procedure. Additional contouring procedures such as liposuction or



• **Fig. 1.16** (A) Significant partial flap necrosis in a delayed pedicled TRAM flap breast reconstruction patient. (B) A pedicled latissimus dorsi flap with a large skin paddle is performed successfully as a salvage procedure for her breast reconstruction after debridement of necrotic tissue.



• **Fig. 1.17** (A) A large bulging area of the lower abdominal donor site in an immediate TRAM flap breast reconstruction patient. (B) The stretched abdominal fascia is plicated first to reduce the size of the weakened area. (C) An onlay synthetic mesh (usually in 4 layers) is placed over the area for additional support.

excess skin excision or skin reshaping are also needed for the reconstructed breast. Fat grafting can also be performed to the reconstructed breast for additional filling or reshaping.

A dog-ear deformity from either side of the lateral lower abdomen can be an issue for the patient. Many patients will

be bothered by even the smallest dog-ear, making it challenging for the surgeon. Dog-ear deformities, when isolated, can be treated under local anesthesia in the clinic setting or during any revision procedure. When nipple–areola complex reconstruction is desired, the abdominal dog-ear

deformity or further extension of the lateral abdominal scar are excellent sources of a full-thickness skin graft for areolar reconstruction.

True hernia from a TRAM flap abdominal donor site is very rare. However, the weakness of abdominal wall, presented with “bulging,” can be relatively common.¹² We typically perform this operation using permanent material such as Prolene mesh for onlay placement as an additional reinforcement. If the size is large, we plicate the area first to reduce the size of the bulging, combined with an onlay mesh sewn in with permanent suture to strength the repair (Fig. 1.17A–C).

Conclusion

With proper patient selection, several refinements of the flap dissection, adequate closure of the donor site, and effective management of complications, the pedicled TRAM flap breast reconstruction can be performed successfully with a good outcome and minimal flap or donor-site morbidity. The pedicled TRAM flap can be performed by plastic surgeons without microsurgical expertise in most hospitals and its reconstructive outcome can be satisfactory to many patients. It still remains a valid option that can be offered to selected patients for their abdominally based autologous breast reconstructions.

PEARLS FOR SUCCESS

- Proper patient selection and preoperative education are critical for such a breast reconstruction.
- Surgical flap delay can be done to improve the flap's blood supply and to minimize the flap's ischemic complications.
- Preoperative imaging study can be helpful for the flap design so that an optimal side of the flap can be selected and the size of the fascial defect can be minimized after the flap elevation.
- For unilateral TRAM flap breast reconstruction, the entire zones I and II and a portion of zone III are usually used. For bilateral TRAM flap reconstructions, the entire zone I and a large portion of zone III are used for each side.
- Abdominal donor site should be closed meticulously and reliably with either onlay (for unilateral) or inlay (for bilateral) mesh.
- Complications such as partial flap loss and abdominal skin flap necrosis should be managed promptly and effectively.
- Persistent abdominal bulging can be a problem and should be managed properly with mesh reinforcement with or without fascial plication.

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2

Free or Free Muscle-Sparing TRAM Flap Breast Reconstruction

JESSICA F. ROSE AND LIZA C. WU

► Introduction

Abdominally based reconstructions have been utilized for the last 40 years. In 1979, Holstrom used tissue normally discarded from abdominoplasty as a free flap for breast reconstruction.^{1,2} In 1982, Hartrampf described and popularized the pedicled TRAM (transverse rectus abdominis muscle) flap.²⁻⁴ In 1989, Grotting improved upon the design and began using free TRAM flaps based off the deep inferior epigastric artery (DIEA) as opposed to the superior epigastric arteries (as in the pedicled TRAM).^{3,4} The advantages included improved blood supply, more limited muscle harvest, and fewer complications than the pedicled version.^{3,4} The final iteration evolved into a perforator flap, described by Allen and Treece in 1994 as the deep inferior epigastric artery perforator (DIEP) flap, to minimize abdominal donor site morbidity.²

As one can infer from the historical modification, there are many differing flaps that are available from the abdomen, ranging from pedicled versions to perforator-based free flaps. The pedicled TRAM flap based off the superior epigastric artery is associated with the most abdominal wall morbidity. It also has higher partial flap loss and fat necrosis rates, as the superior epigastric artery is the non-dominant blood supply. This option is likely better reserved for when microsurgery is not available or feasible.⁵ If microsurgery is an option, the free flap versions are preferable reconstructions, and are based off the blood supply from the DIEA. Advantages include improved blood supply, easier flap manipulation, and more mobility for flap inset. However, the use of microsurgery makes this option more challenging, resulting in a longer operation with a higher risk of total flap loss.^{2,5} In this chapter, we will discuss the indications for a free TRAM and the preoperative evaluation, describe the relevant surgical anatomy and the procedure, and review the postoperative care and management of complications.

Indications and Contraindications

In our practice, most patients are candidates for free or MS-TRAM breast reconstruction, presuming that they have an appropriate amount of abdominal donor tissue and do not have multiple of the previously mentioned risk factors. High-risk patients include active smokers, the obese, those requiring postoperative radiation, patients with hypercoagulable states, and those who have had prior abdominal surgery. Smokers are at higher risk of mastectomy skin necrosis, fat necrosis, and abdominal flap necrosis.³ Obese patients (BMI >30) are at higher risk for mastectomy skin necrosis, donor- and recipient-site complications, and partial flap loss.^{3,5} Patients who need radiation will experience dermal fibrosis and possible changes in flap volume. Patients with a prior history of abdominal surgery have a higher rate of delayed healing, typically requiring greater amounts of muscle to be harvested. Preoperative imaging should be considered in this patient group.⁵ Age has not shown to be a risk factor for autologous breast reconstruction, although patients over age 65 have a higher rate of venous thromboembolism and hernia.⁵

Although not a contraindication to autologous reconstruction, a significant dilemma are patients with large breasts and small, insufficient donor sites to provide tissue to rebuild their mastectomy defect.⁵ We offer these patients several options, the most common of which is to use stacked flaps to reconstruct a unilateral breast, with one antegrade and one retrograde anastomosis. For bilateral reconstructions, a latissimus flap combined with an abdominal free flap, stacked free flaps from multiple donor sites, and free flaps with fat grafting and/or implants are all options.

Another challenging group are patients with a history of thrombotic conditions and/or a history of deep vein thrombosis (DVT)/pulmonary embolism (PE).⁵ Approximately 5%–10% of the population is estimated to have a hypercoagulable state, although in many it is unrecognized

preoperatively. We still offer these patients microvascular breast reconstruction, but our perioperative management changes. These patients are counseled that they are about 5 times more likely to have a thrombosis than the average patient (approximately 20% of hypercoagulable patients at our institution) and have a much higher risk of flap loss if a thrombosis occurs (15.5% vs 1.8%). Our intraoperative management of these patients includes the addition of a heparin bolus and a heparin drip continued postoperatively. Our studies have shown that this reduces flap loss rates to the range seen in patients with normal coagulation profiles, but increases the risk of postoperative blood transfusion. Postoperative management ranges depending on the nature of their thrombotic conditions but typically includes heparin drips, therapeutic doses of enoxaparin, aspirin and/or clopidogrel.⁶

Preoperative Evaluation

All patients undergo standard medical clearance for surgery, and patients with cardiac or pulmonary co-morbidities require subspecialty clearance. Obese patients are considered on a case-by-case basis depending on their body mass index and the distribution of their body fat. The only people we will not operate on are those who are not medically cleared for surgery.

Patients who require postoperative radiation are still candidates for free MS-TRAM flaps. In these patients, timing of the reconstruction in relation to radiation is a consideration. Traditionally, these patients were only offered delayed reconstruction about 6 months after completion of post-mastectomy radiation.⁵ Many patients who present to our practice have been treated with mastectomy and radiation at outside institutions and are candidates for delayed breast reconstruction. In patients who present to us before they undergo mastectomy and radiation, we offer them a choice of delayed or immediate reconstruction. Those who choose immediate reconstruction are advised about the potential for radiation to cause changes to their flap that may alter the final aesthetics.

Another consideration when assessing these patients before surgery is whether imaging is required for surgical planning. Many surgeons choose to preoperatively image patients with a computed tomography angiogram (CTA) to aid in surgical planning, as it can help with perforator row choice, spare muscle, and speed dissection. However, this is controversial due to cost, nephrotoxicity of the contrast dye, and radiation exposure.⁵ We do not routinely image patients as we feel we can identify intraoperatively which row or rows of perforators to take with or without a small amount of rectus muscle. The exception is patients with multiple abdominal surgeries where perforators or deep inferior epigastric (DIE) vessel patency are questionable. In most instances, patients are offered or undergo an MS-TRAM. Essentially, we no longer perform a free TRAM unless the perforators are violated and we feel the flap requires the entire muscle to achieve viability.

There are a few clear-cut indications for MS-TRAM over DIEP, and these include patients with multiple small perforators scattered throughout the rectus muscle, patients requiring large reconstructions (>1000 g), patients who smoke and/or those who will require post-mastectomy radiation therapy.⁷ Because of the inclusion of more muscle and therefore blood supply, perfusion of MS-TRAM is better than for the DIEP. Studies assessing muscle function have shown muscle harvest to be associated with weakness, but the clinical correlation has not been proven and patient questionnaire studies have been equivocal.²

Surgical Techniques

Relevant Surgical Anatomy

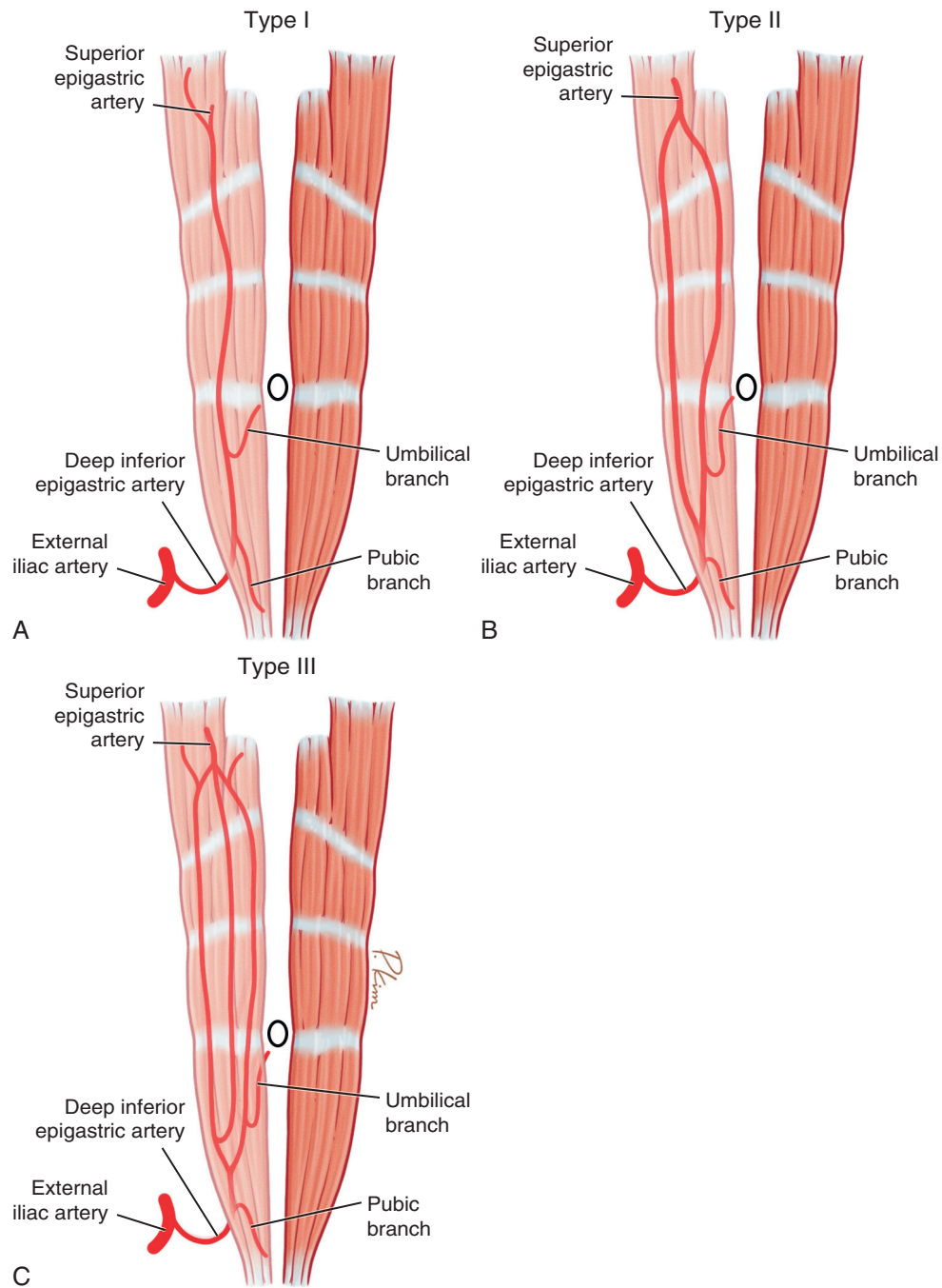
Donor Site Blood Supply

The blood supply of the free and MS-TRAM flaps are based on the DIEA. The difference between the two flaps depends on how much muscle is taken with the flap, as described in the introduction. The DIEA has three different branching patterns (Fig. 2.1): type I, where the DIEA is a single intramuscular vessel; type II (the most common), where the DIEA splits into two distinct intramuscular branches; and type III, where the DIEA divides into three branches.⁸ The most common pattern is currently described as the medial and lateral rows, and it is from these rows that the perforators branch into the adipose tissue and supply the flap skin via the subdermal plexus. As you would expect based on their location, medial perforators are more likely to perfuse across the midline, while lateral perforators are more likely to perfuse the lateral/distal portion of the flap. Venous drainage follows the arterial system and typically both the superficial epigastric and deep epigastric veins are connected by the venae comitantes to drain the flap.⁹

Classically, the arterial supply has been documented into cutaneous zones (Fig. 2.2). Originally, these zones were named by Hartrampf and were considered for pedicled TRAM flaps, with zone I being directly on top of the muscle, zone II on the contralateral muscle, zone III lateral to zone I, and zone IV lateral to zone II. Ninkovic and Holm re-classified to have zone I directly on muscle and zone II the adjacent lateral zone, which is more pertinent to free flap morphology.⁵

Recipient Vessels

There are options to choose from in terms of recipient vessels to anastomose the flap. Historically, the thoracodorsal vessels were used but there has been a shift to using the internal mammary (IM) vessels. Either vessel is usable but IM flow is higher, which is preferable if a retrograde anastomosis is necessary. IM and thoracodorsal vessels are similarly sized (1–2.5-mm artery and 1–4-mm vein) and are both considered large vessels with reliable flow.^{4,5} The IM artery has consistent size between 3rd and 5th interspace^{4,5}



• **Fig. 2.1** Branching patterns of the deep inferior epigastric artery. (A) Type I. (B) Type II. (C) Type III.

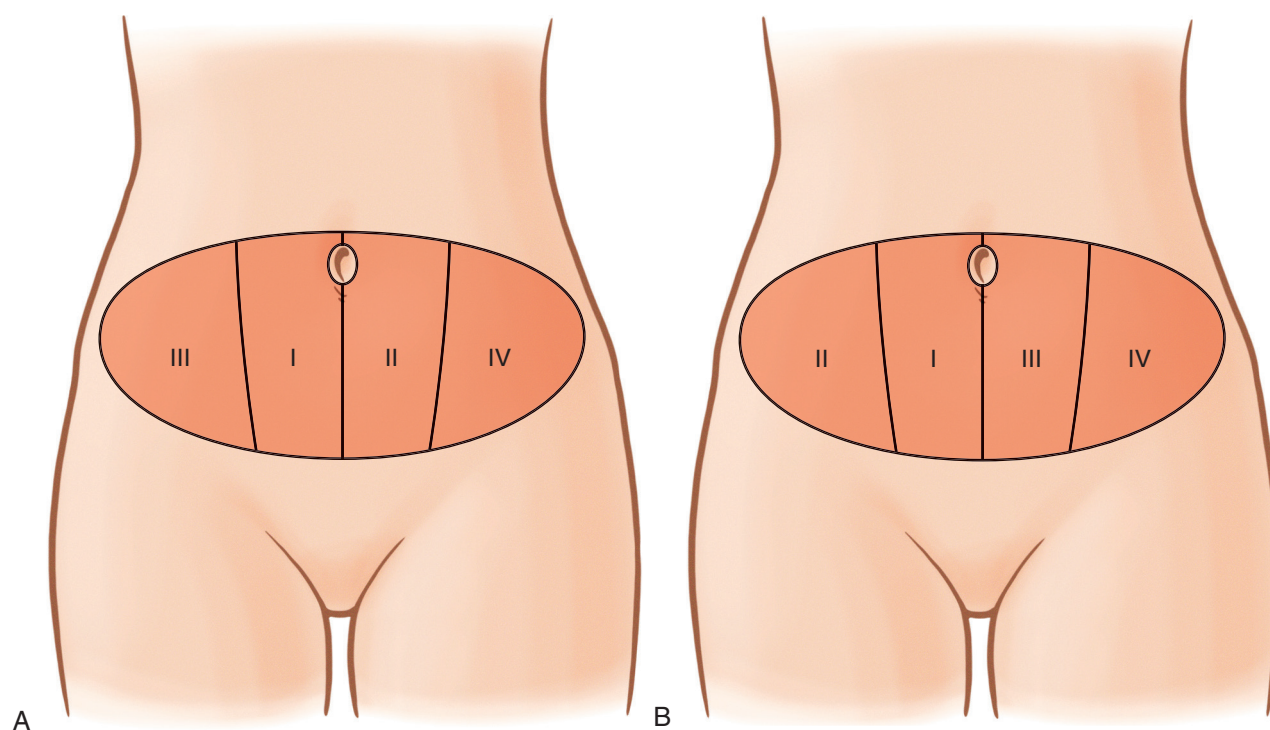


Fig. 2.2 Cutaneous zones of the TRAM flap. (A) Hartrampf zones. (B) Ninkovic/Holm zones.

with a vein bifurcating at 4th interspace.⁵ The IM vessels have a predictable location, they are usually in a low scarred area and easy to get to, and they can help with breast aesthetics by allowing the flap to be inset in a more medial position to re-create cleavage.⁴ Conversely, inflow injury can happen if the patient has a thoracodorsal anastomosis and ends up needing an axillary dissection, although there is a small risk of inadvertent pleural entry and pneumothorax with the IM vessels.⁵ Fig. 2.3 shows the internal mammary artery anatomy.

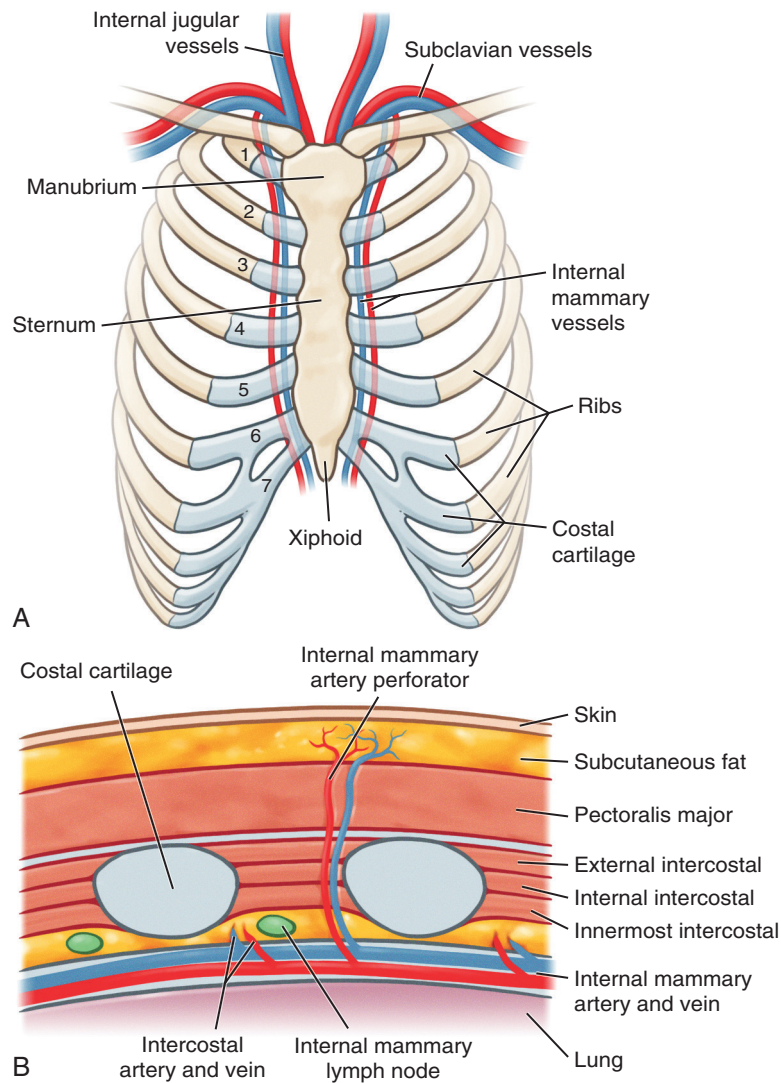
Different Varieties of the Free TRAM

There are different varieties of the free TRAM depending on how much of the muscle is either utilized or spared. Following the classification system described by Nahabedian (Fig. 2.4), the MS-0 takes full width of rectus, MS-1 preserves lateral or medial segment, MS-2 preserves some of both lateral and medial segments, and MS-3 preserves the whole muscle (a perforator flap like the DIEP).⁵ There are specific advantages and disadvantages for each option. The MS-0 free TRAM takes the entire width of the muscle, therefore preserving the entire vascular supply. This option is best for patients who may be at risk for partial flap loss with the more muscle-sparing techniques. It sacrifices the entire width of muscle like the pedicled TRAM but is less prone to fat necrosis.^{2,5} These patients are more likely to be able to perform a sit-up than a patient with a pedicled TRAM, although most studies showed

no objective difference in muscle strength.² Overall, free TRAM patients report good satisfaction and would have made the same reconstructive decision again.⁹ Muscle-sparing versions (MS-1 and MS-2) of the free TRAM maintain a portion of the neurovascular supply, therefore preserving more muscle and decreasing abdominal wall morbidity.^{2,5,10} The DIEP (MS-3) spares all muscle. The major advantage of this technique is less abdominal wall morbidity, yet this operation has decreased vascularity with a higher risk of venous insufficiency, partial flap loss, and fat necrosis compared with free TRAM flaps. In addition, this operation is more technically challenging and time consuming.^{2,5,7,11}

Preoperative Markings

We mark our patients in a standard fashion and make modifications depending on the patient's body habitus. For immediate reconstruction patients, we mark the midline and the inframammary fold (IMF) with a solid line and sometimes use hash marks to define the upper breast borders when the patient is in standing position. The mastectomy incision pattern is marked in a variable fashion depending on whether the patient is a candidate for nipple-sparing mastectomy, skin-sparing mastectomy, or whether she needs skin resected to treat her malignancy. For nipple-sparing mastectomy patients we favor a periareolar incision that starts a quarter of the way around the areola and



• **Fig. 2.3** Internal mammary anatomy. (A) Pathway of the internal mammary vessels behind the costal cartilages. (B) Cross-sectional anatomy of the layers above the internal mammary vessels.

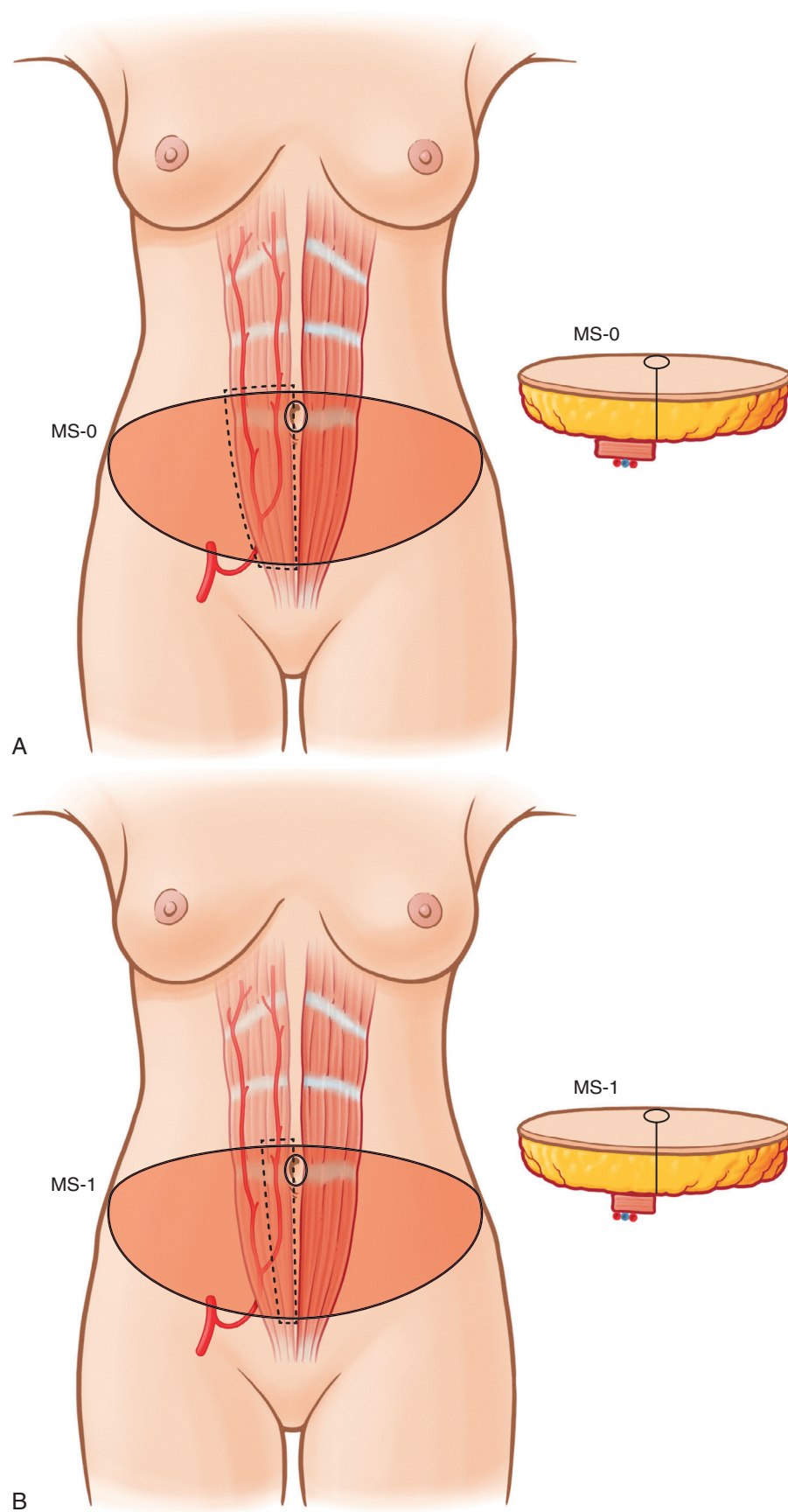
extends inferiorly. For skin-sparing mastectomy patients, the patient's degree of ptosis will also dictate the type of incision to be made. For those with no or mild ptosis, we choose a periareolar incision, and for moderate or severe ptosis, we utilize a circumvertical incision pattern (Fig. 2.5). The abdomen is marked with the patient in the standing position. The superior incision is marked to incorporate the periumbilical perforators. The inferior incision is marked with the pinch test and confirmed intraoperatively with the patient in the Fowler position.

For patients undergoing a delayed reconstruction we mark the midline similarly. If the contralateral breast is present we mark it as stated above and transpose the level of the superior breast margin and IMF to the mastectomy site (Fig. 2.6). If bilateral mastectomies have been performed

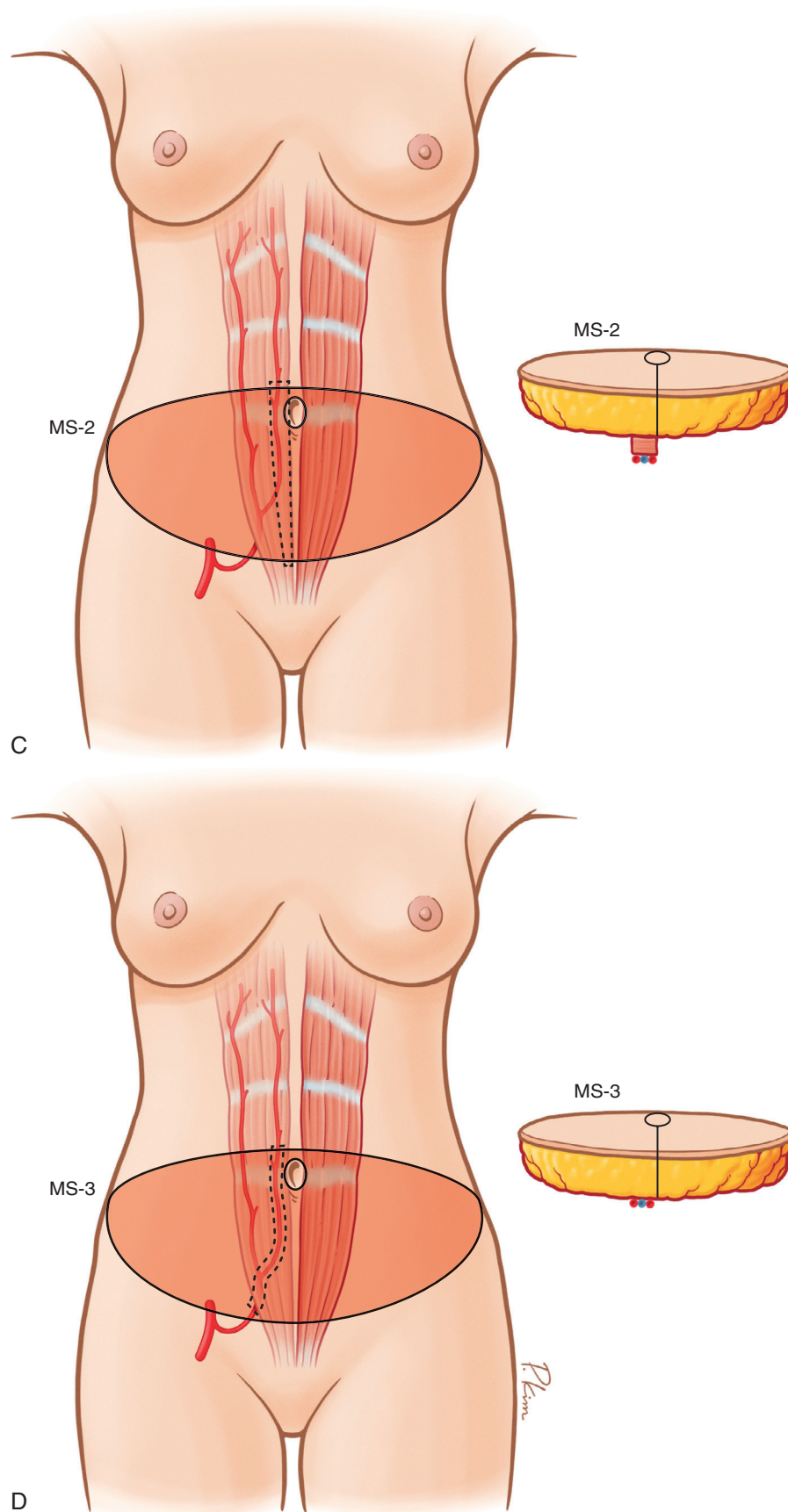
previously, we choose an area to mark the IMF and superior breast margins to be bilaterally symmetric and congruent with the patient's anatomy.

Surgical Exposure

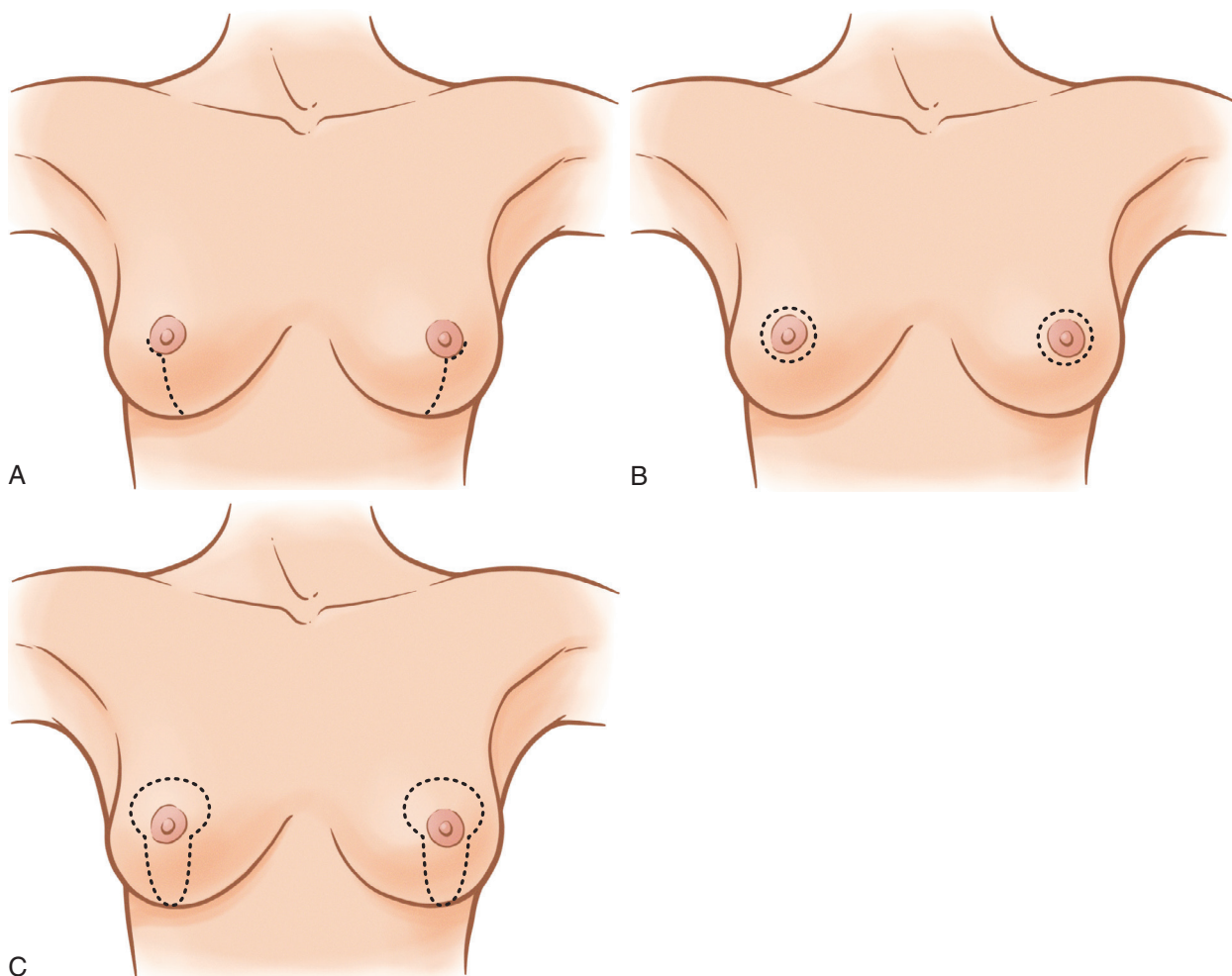
We prefer to use a two-team approach in order to maximize efficiency and minimize anesthesia and operating room time. For immediate reconstructions, the oncologic team performs the mastectomy(ies) and any lymph node biopsies or dissections while the plastic surgery team is dissecting out the abdominal flaps. In delayed reconstructions, we have two plastic surgery teams, one to isolate the recipient vessels and another to dissect the abdominal flaps.



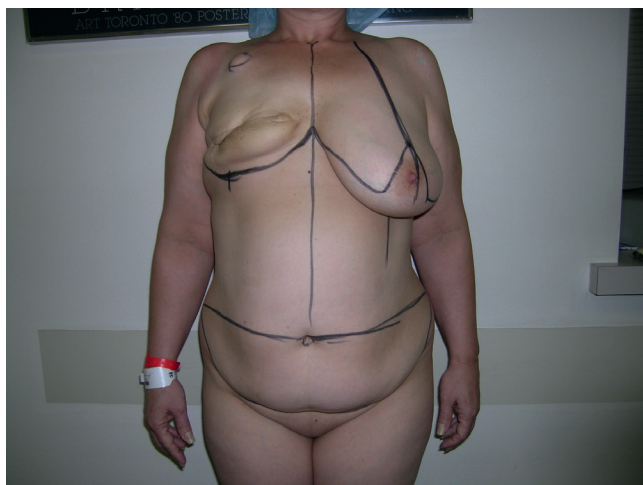
• **Fig. 2.4** Nahabedian classification for free TRAM flaps. (A) MS-0, or free TRAM. (B) MS-1 or muscle-sparing free TRAM preserving either medial or lateral segments.



• **Fig. 2.4, cont'd** (C) MS-2 or muscle-sparing free TRAM sparing both medial and lateral segments.
(D) MS-3 or DIEP flap.



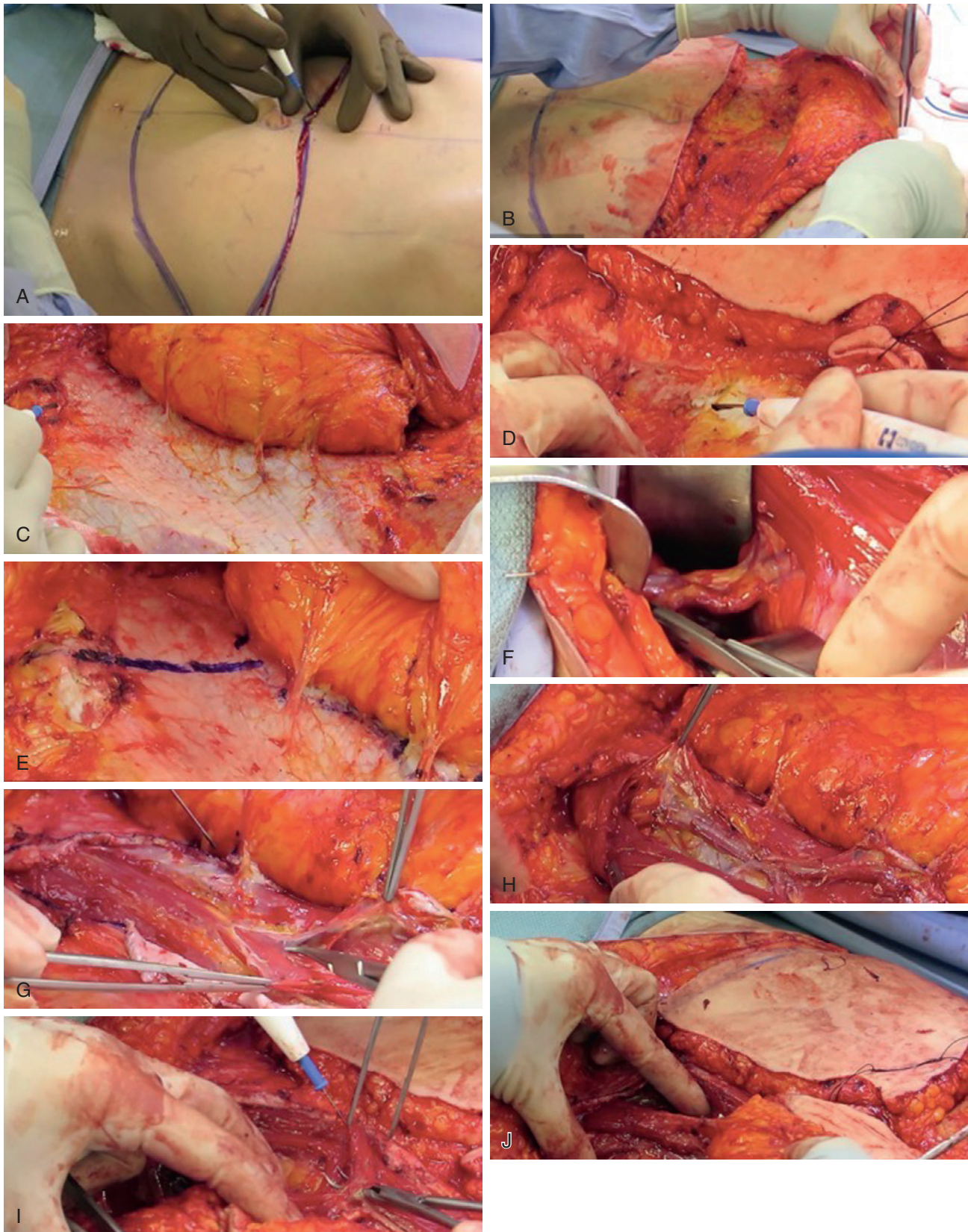
• **Fig. 2.5** Mastectomy skin markings. (A) Markings for nipple-sparing mastectomy. (B) Skin-sparing mastectomy markings for patients with minimal ptosis. (C) Skin-sparing mastectomy markings for patients with minimal ptosis.



• **Fig. 2.6** Patient markings. This patient is undergoing a delayed reconstruction with a contralateral reduction. Markings are shown on the abdomen and area of the absent breast as described.

Donor-Site Operation (MS-TRAM)

We begin the reconstructive portion of the operation with the elevation and dissection of the abdominal flap. The entire procedure is completed using 3.5× loupes, including the microsurgical anastomosis. The skin markings are incised with a #10 surgical scalpel. We incise the upper incision first (Fig. 2.7A) and then elevate the upper abdominal wall to determine how much skin can safely be removed while allowing primary closure (Fig. 2.7B). The umbilicus is also incised circumferentially and sharply dissected out down to the level of the fascia. The inferior portion of the incision is made and the superior inferior epigastric vein (SIEV) is dissected out on both sides. The lateral portions of the abdomen are dissected off of the abdominal wall until the rectus muscle is reached medially. At this level, we begin to look for perforators (Fig. 2.7C). The



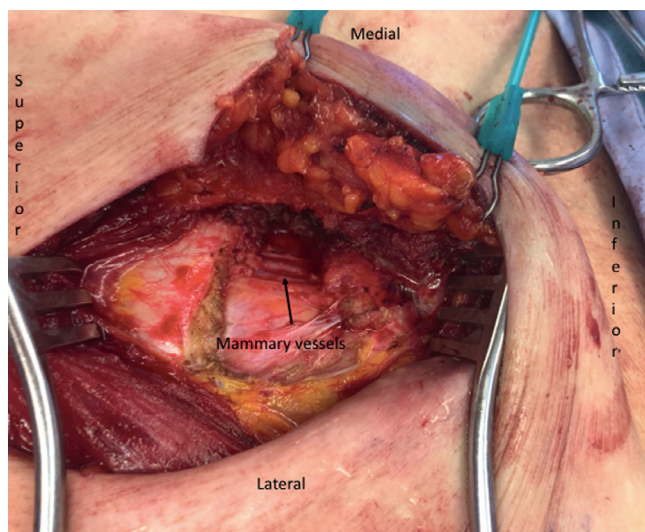
• **Fig. 2.7** Key steps in the elevation of the abdominal flap. (A) Making the upper incision. (B) Elevating and retracting the upper skin flap. (C) After the lateral row has been isolated. (D) Dissecting out the medial row. (E) Marking the fascial incision. (F) Pedicle dissection. (G) The lateral muscle split. (H) Exposure of the pedicle through the lateral muscle split. (I) Medial muscle split. (J) Flap isolated on a small piece of muscle.

majority of our reconstructions are bilateral and utilize one hemi-abdomen per breast. Therefore, we split the donor site down the midline and dissect medially until we visualize the medial rectus perforators (Fig. 2.7D). Once both rows of perforators are visualized we determine perforator topography.

Once we arrive at the level of the perforators we incise the anterior rectus fascia caudally (Fig. 2.7E) and dissect out the DIE vessels to assess patency (Fig. 2.7F). The perforator topography is delineated and we decide which perforators to choose to profuse the flap. The fascia is incised around the perforators, sparing as much as possible. We follow the perforators to the pedicle, splitting and sparing the muscle in the process (Fig. 2.7G–I). Once the flap is isolated on its pedicle we leave it *in situ* until the mastectomies are complete (in immediate reconstructions) (Fig. 2.7J) and the recipient vessels are prepared.

Recipient Vessel Preparation

We use the internal mammary vessels as the preferred recipient vessels for our anastomosis. Once either the mastectomy is complete or the prior mastectomy site is re-elevated we palpate the intercostal space between the third and fourth ribs. If the space is large enough, we prefer a rib-sparing approach. If not, we excise the medial costal cartilage of the 3rd rib. The pectoralis muscle is split and intercostal muscles are removed to appropriately expose the space. The vessels are dissected free for the length of the intercostal space. We also frequently find it necessary to either re-create or reinforce the anatomic footprint of the breast at the inframammary fold and lateral breast border with sutures (Fig. 2.8).



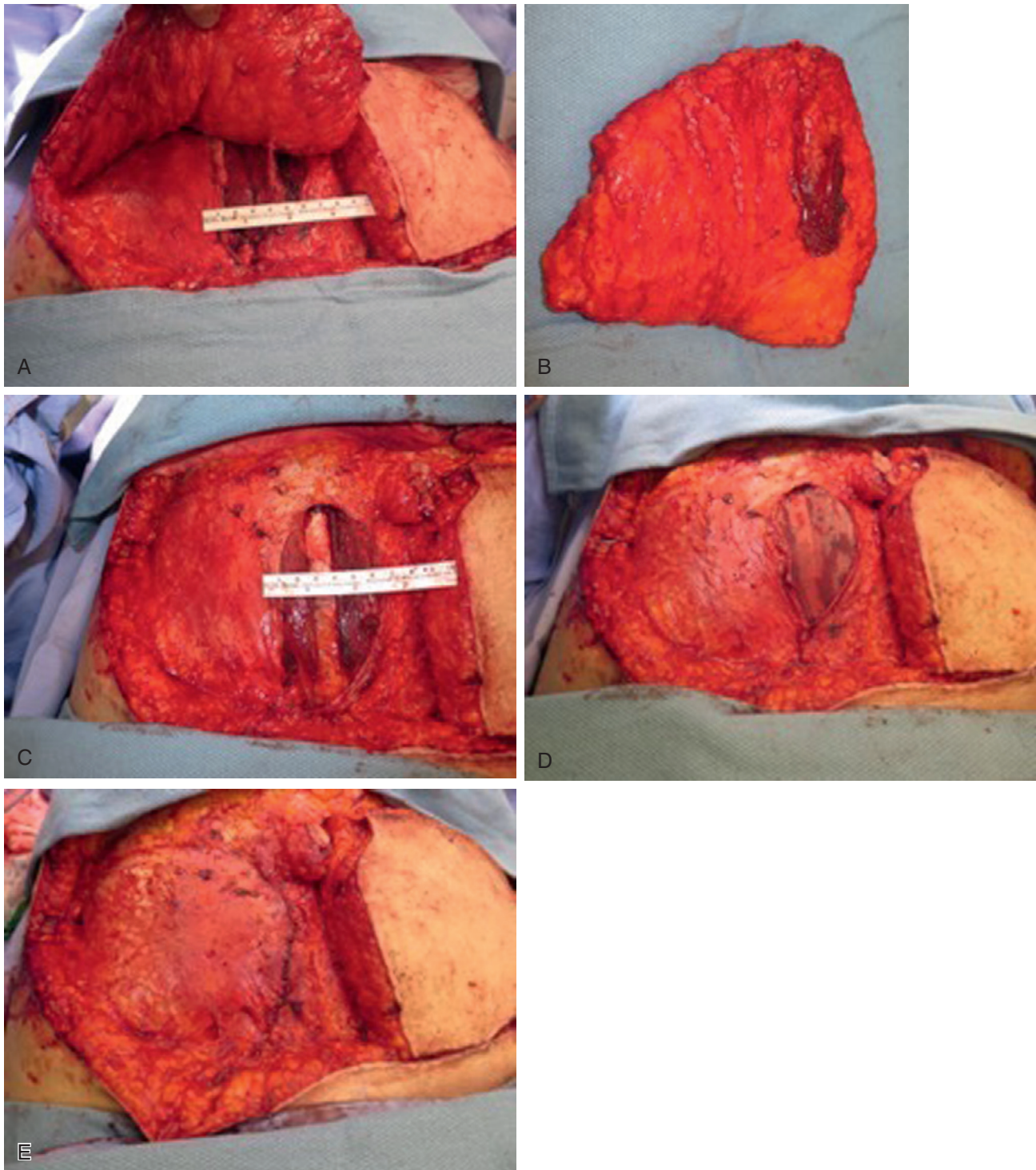
• Fig. 2.8 Exposure of internal mammary vessels.

Completion of Flap Elevation

Once the internal mammary vessels are prepared, the flap vessels are ligated at their origin, just distal to their take-off from the external iliac vessels, and the flap is transferred to the chest. The contralateral flap is used and rotated 90 degrees so that the vessels lie gently within the intercostal space. The vessels are temporarily clamped with Acland clamps to keep a dry surgical field. The internal mammary vessels are divided distally. The vein is anastomosed first using an appropriately sized coupler (typically 3.0 mm) and then the arterial anastomosis is performed end-to-end with 8-0 interrupted nylon sutures. The clamps are removed and flap viability is assessed. The flap is inset into the mastectomy defect and any buried aspects are de-epithelialized. The flap is oriented so that the contralateral flap is used. The flap is rotated 90 degrees so that the lateral aspect of the flap is oriented superiorly and the area next to the umbilicus is inferior and lateral. We suture Scarpa's fascia of the flap to the chest wall to keep it in proper position. During this process we re-check the pedicle to make sure that it does not have any twists or kinks. We place sutures at several places, mostly to keep the flap medialized to re-create cleavage. We use 2-0 polyglactin 910 (Vicryl, Ethicon US, LLC, Somerville, NJ) to secure the flap. All flaps get secured medially, superiorly, and at the inframammary fold, but additional sutures can be used as needed to shape the breast appropriately. Two drains are placed (one superior and one inferior) and the breast incisions are closed using Vicryl, deep sutures in Scarpa's fascia, and 3-0 Glycomer 631 (Biosyn, Covidien-Medtronic, Minneapolis, MN) deep dermal, and 4-0 Glycomer 631 (Biosyn, Covidien-Medtronic, Minneapolis, MN) subcuticular running sutures.

Donor Site Closure

The abdominal fascia is closed using either underlay or bridging polypropylene (Prolene, Ethicon US, LLC, Somerville, NJ) mesh that is inset with 0 polypropylene (Prolene, Ethicon US, LLC, Somerville, NJ) sutures. Mesh is always placed underlay, unless the fascia is unable to be closed, in which case it is used in a bridging fashion. For images of the donor site and fascial closure, see Fig. 2.9. Elastomeric pain pumps (OnQ, Irvine, CA) are placed bilaterally or conversely a transversus abdominis plane block is performed with 0.5% bupivacaine (Marcaine, Pfizer, New York, NY). Next, two drains are placed, one on either side of the abdomen. The drains are brought out either end of the incision and secured with 2-0 Prolene sutures. The skin flap is advanced down and the patient is flexed at the waist to take tension off the incision. Scarpa's fascia is closed using 2-0 Vicryl deep sutures. The skin is closed using 3-0 Biosyn deep dermal interrupted sutures and 4-0 Biosyn subcuticular running sutures. The umbilicus is brought up using a separate incision in the midline and inset using 3-0 and 4-0 Biosyn sutures.



• **Fig. 2.9** (A) Flap elevated on both rows of perforators showing the intended muscle resection. (B) Detached flap showing the amount of muscle resected with the flap. (C) Donor-site defect after the flap has been removed. (D) Donor site with mesh underlay in place. (E) Donor site with fascia closed over the mesh repair.

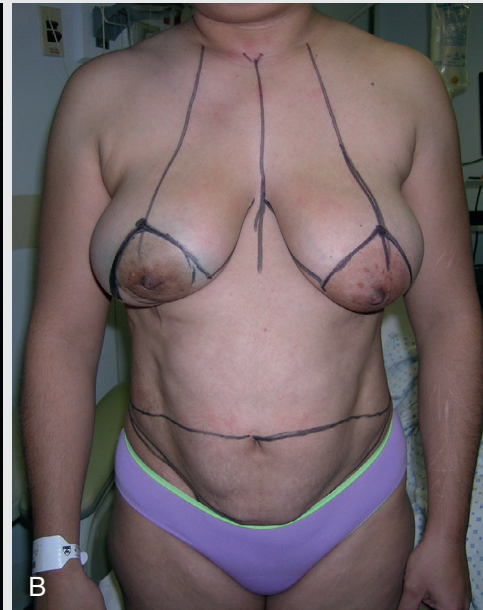
Case Examples

CASE 2.1

Immediate, Unilateral

Case 2.1.1 shows a patient with a right-sided breast cancer and some breast asymmetry who is undergoing an immediate unilateral breast reconstruction with a left balancing reduction. (A) Preoperative images, showing some skin retraction near the

nipple where the tumor is located. (B) Preoperative markings for the resection on the right and the balancing reduction on the left. (C) Postoperative result before nipple reconstruction and tattoo.



• Case 2.1.1

CASE 2.2**Delayed, Unilateral**

Case 2.2.1 shows the patient previously depicted in Fig. 2.6. She had prior treatment of a right-sided breast cancer with mastectomy and post-mastectomy radiation therapy. She presented for delayed right breast reconstruction with

balancing left reduction. (A) Preoperative image. (B) Postoperative result before nipple reconstruction. (C) Postoperative result after nipple reconstruction but before areola tattoo.



• Case 2.2.1

CASE 2.3**Immediate, Bilateral**

Case 2.3.1 shows a patient with a unilateral malignancy who chose to have a contralateral mastectomy for risk reduction. She underwent skin-sparing mastectomies and had an

immediate reconstruction. (A) Preoperative photo. (B) Postoperative photo after nipple reconstruction and tattooing.

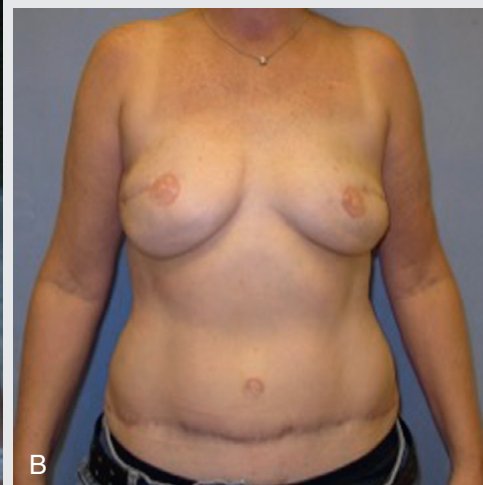
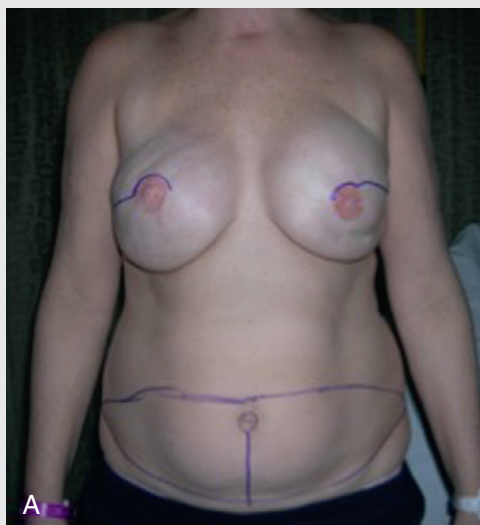


• Case 2.3.1

CASE 2.4**Delayed, Bilateral**

Case 2.4.1 shows a patient who presented after a previous implant-based reconstruction. She was dissatisfied with the cosmetic result and had pain and capsular contractures

associated with the implants. She underwent a delayed free flap breast reconstruction. (A) Preoperative photos showing her prior reconstruction. (B) Postoperative photo.



• Case 2.4.1

Postoperative Care and Expected Outcomes

As soon as the procedure is completed the patient is transferred to either the ICU or step down unit (depending on the institution and available options) for hourly free flap checks. For the first 48 hours, we monitor our flaps hourly, by checking the color, warmth, and capillary refill of the flap along with external Doppler signals at a marked suture. This is transitioned to every two hours for the subsequent 48 hours and then every four hours if the patient remains hospitalized. We typically only used enoxaparin 40 mg subcutaneously daily or heparin 5000 units subcutaneously every 8 hours for DVT prophylaxis and do not employ any other anticoagulation (exception is for hypercoagulable patients as previously mentioned). The patients are kept on bed rest and are positioned in the semi-Fowler position with their feet elevated and sequential compression devices (SCDs) on their calves. They are transitioned to a chair and ambulation on postoperative day (POD) 1. Initially, patients are kept NPO but are converted to a clear liquid diet and advanced as tolerated on the morning of POD 1. All patients are kept on prophylactic antibiotics. We employ a multimodal pain control regimen, which includes a patient-controlled analgesia (PCA) pump (either morphine or hydromorphone), ON-Q pain pump, acetaminophen, and occasionally diazepam.

Our patients' breast incisions are dressed with 3% bismuth tribromophenate gauze (Xeroform petrolatum gauze, Covidien-Medtronic, Minneapolis, MN) and their abdominal incisions are dressed with 2-octylcyanoacrylate glue (Dermabond, Ethicon US, LLC, Somerville, NJ). All of our patients have 1–2 drains per surgical site that are stripped and emptied every 4 hours and as needed. Drains are removed after they have put out 30 mL/day or less for two consecutive days. Patients are allowed to wear a light support bra or camisole.

Patients typically remain hospitalized for 4 days. The initial two days are either in an ICU or step down unit, and then they are transitioned to the regular room. Patients are followed up initially about one week postoperative. Subsequent follow-up is determined by need for drain removal. Once drains are removed, patients are seen again at 6 weeks, 3 months, 6 months, and 1 year, and then seen annually.

Most patients have a favorable outcome and are pleased with the aesthetic result of the reconstruction. The goal of the initial operation is to transfer the abdominal tissue to the chest wall in a reliable fashion, to recreate a viable breast mound. For unilateral reconstructions, we perform contralateral symmetry operations including augmentation, mastopexy, and reduction concurrently with the reconstruction. Despite initial concern for an aesthetic result, it is not uncommon for patients to require or desire some small secondary refinement procedures, like nipple–areola reconstruction, excision of skin paddle from monitor segment, fat grafting, scar revision, and liposuction.

Secondary procedures are performed no sooner than 3 months after the initial reconstruction, or 6 months after radiation in those requiring post-mastectomy radiation therapy.

Management of Complications

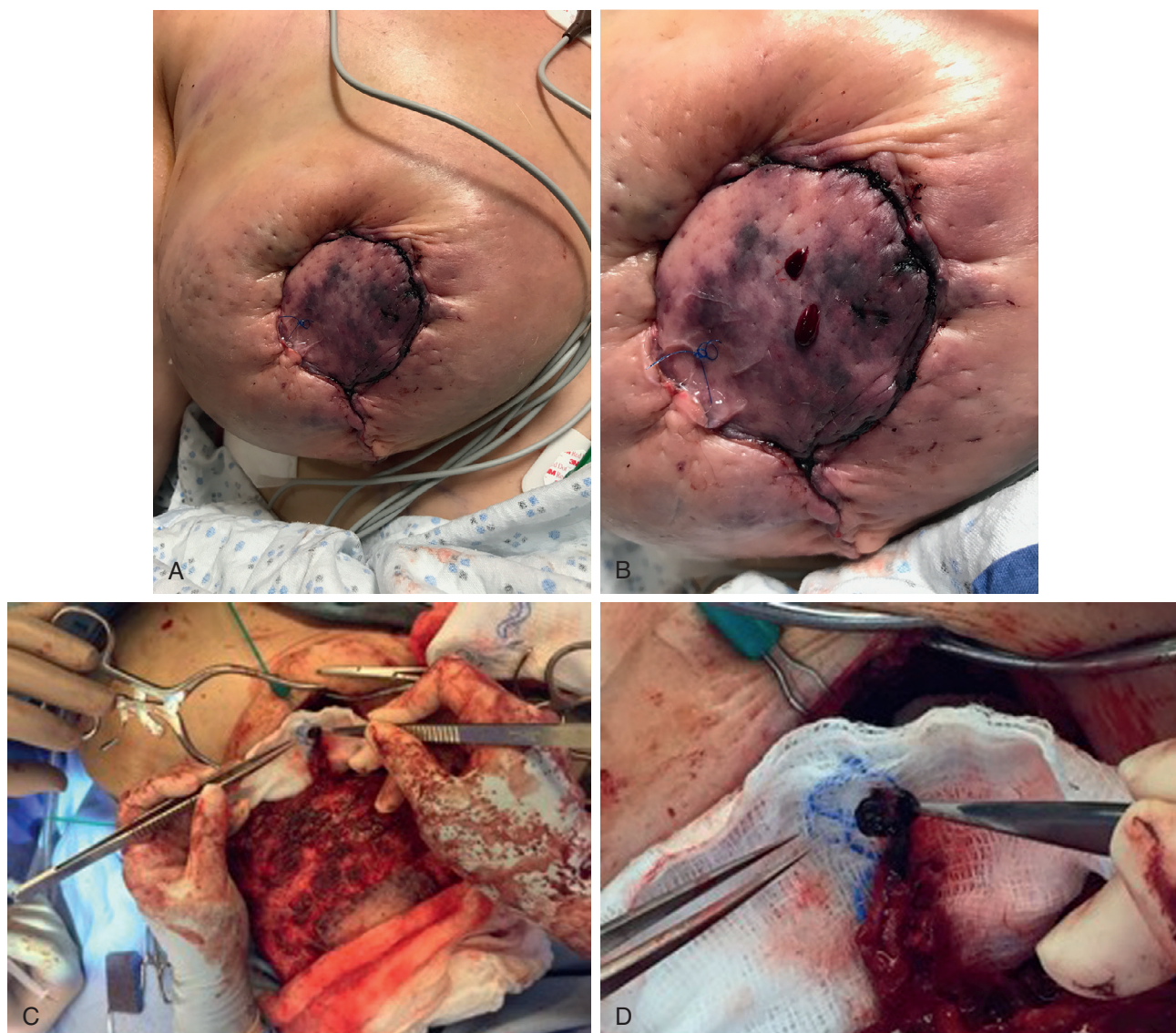
The most common complications for free or MS-TRAM flaps are wound infection in 3%–7% of patients,^{3,5} skin flap necrosis of either the abdomen or breast skin (both about 3%), partial flap loss of about 1.5%,^{3,12} 2.6% delayed wound healing,³ fat necrosis rates of up to 25%,^{3,5} hematoma (<1%), and seroma (1.2%). Partial and total flap loss are rare (less than 1%; typically closer to 0.3% but 1%–6% range reported in the literature)^{3,5} but can occur, as can unexpected return to the OR for hematoma (0.8%), arterial thrombosis (0.5%), and venous thrombosis (1.4%).³

If complications occur they are managed accordingly. Certain complications can have a serious impact on the flap and need to be managed urgently. Strict flap monitoring protocols allow us to readily diagnose hematomas, venous congestion, and arterial thrombosis, so that these patients can be immediately returned to the operating room for management and flap salvage. In the operating room these patients are explored, hematomas are washed out and hemostasis is obtained. Flap viability is assessed and if compromised the anastomosis is explored. If necessary either the vein, artery, or both are revised. The anastomosis is taken down, mechanical thrombolysis, streptokinase, systemic heparin, repeat anastomosis, and vein grafting are all employed as needed in order to salvage the flap. Typically, after salvage the patient is anticoagulated with systemic heparin. See Fig. 2.10 for an example of a flap with venous congestion.

Delayed wound healing is typically managed with local wound care and dressing changes or negative pressure therapy and allowed to heal by secondary intention. Seromas are treated with aspiration and drainage if necessary. Fat necrosis is managed on a case-by-case basis. If it is sufficiently bothersome to the patient, it can be treated with excision.

Secondary Procedures

Secondary procedures to improve the aesthetic outcome are commonly performed and are the norm. Common problems are discrepancies in shape, volume, contour, and poor scarring. The tools we utilize are liposuction, fat grafting, tissue rearrangement, and addition of implants. Generally speaking, volume discrepancies can be managed by reducing the larger breast with a formal reduction mammoplasty or liposuction or by augmenting the smaller breast with an implant or fat grafting (depending on the amount of volume required). Occasionally the reconstructed breast settles in a position that is more caudal than desired, and the breast can be lifted. This can be done by excising redundant skin



• **Fig. 2.10** Flap compromised by venous congestion. (A) Flap showing signs of venous congestion. (B) Close-up showing congested flap with dark venous blood from needle stick. (C) Intraoperative exploration with salvage by revision of venous anastomosis and mechanical thrombectomy. (D) Close-up of mechanical thrombectomy.

and mobilizing the flap into a more superior position or employing a more traditional mastopexy incision pattern, depending on whether the patient has a nipple-areola complex and the location of surgical scars. If a monitoring skin paddle was left it can be excised and closed in a linear fashion to improve appearance. Scars can be revised as needed. Nipple-areola complexes can be reconstructed and tattooed.

We take extra care closing the donor site to mitigate the development of a hernia or abdominal bulging. If a patient has developed a true hernia, we operate and repair it using underlay mesh and primary repair of the defect (if possible). If the patient has a bulge, and not a true hernia, we repair

it with fascial plication and an onlay mesh. See [Fig. 2.11](#) for an example of a patient who developed a hernia.

Conclusions

We feel that MS- or free TRAM is the ideal autologous option in most patients. The abdominal donor site is typically available, and its volume and skin quality more closely resemble native breast tissue than other donor sites. Taking a small amount of muscle with the flap will allow a more streamlined operation, incorporating more perforators and creating a more reliable flap while minimizing the donor-site complications.



• **Fig. 2.11** This patient is a smoker who was overly active and developed a hernia in the immediate postoperative period. (A) Postoperative clinic visit with development of hernia. (B) Lateral view. (C) Intraoperative view of hernia sac showing failure of sutures on the patient's right side. (D) After opening the hernia sac and partial reduction of the hernia. (E) After underlay mesh placement and before fascial closure.

PEARLS FOR SUCCESS

- Free or MS-TRAM is an ideal donor site for breast reconstruction.
- Incorporation of more muscle and perforators helps create a more reliable reconstruction, without substantial donor-site disability.
- Knowledge of the vascular anatomy is necessary to prevent injury to the perforators or the vascular pedicle.
- Careful dissection of the recipient vessels is essential.
- Good technique is required for vascular anastomosis and to ensure appropriate pedicle placement to prevent kinking or tension.
- Re-create breast boundaries lost during mastectomy to shape the breast.
- Proper postoperative monitoring is imperative, so flap problems can be diagnosed and urgently managed to improve likelihood of flap salvage.

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3

Free DIEP Flap Breast Reconstruction

MAURICE Y. NAHABEDIAN

Introduction

Breast reconstruction using the deep inferior epigastric perforator (DIEP) flap has become the gold standard for autologous breast reconstruction for most plastic surgeons.¹ The principle benefit of the DIEP flap compared to other flaps is that the abdomen is the preferred and favorable donor site for most women because many will achieve an improvement in abdominal contour with minimal impairment in function. The DIEP flap utilizes the skin and fat from the lower abdomen but does not harvest any of the underlying rectus abdominis muscle. The deep inferior epigastric artery and vein are dissected away from the muscle, thus preserving the continuity and innervation of the rectus abdominis.

This chapter will provide an in-depth review of the DIEP flap and provide case examples to assist the reader with understanding the risks and benefits of this operation. Other relevant topics will include a review of algorithms, monitoring techniques, and the current technological advancements that have facilitated the ability to perform this operation.

Indications and Contraindications

Indications for the DIEP flap are numerous and include but are not limited to patient demand, dissatisfaction or failure of prosthetic devices, and previous radiation therapy.^{2,3} Although autologous reconstruction is performed less frequently than prosthetic reconstruction, many patients do not want prosthetic devices and prefer using their own tissues. DIEP flaps can be performed immediately following mastectomy or on a delayed basis. This flap is considered in patients with a variety of breast sizes and ultimately depends upon the amount of skin and fat available in the abdominal area to reconstruct a breast of desired shape, volume, and contour.

Contraindications to the DIEP flap are mildly controversial. Some surgeons feel that DIEP flaps should not be performed immediately following a mastectomy if postoperative radiation therapy is likely due to the possibility of flap shrinkage and soft tissue distortion; however, others feel that these adverse events are infrequent and therefore

perform the DIEP flap regardless of radiation.^{4,5} Other contraindications to performing the DIEP flap include the lack of a suitable perforator. This can be assessed preoperatively using vascular imaging modalities such as computerized tomographic angiography (CTA) or magnetic resonance angiography (MRA).⁶⁻⁹ In patients with severe abdominal lipodystrophy with a large pannus, the DIEP flap may not be ideal due to the thickness of the flap and the likelihood of fat necrosis; however, proper tailoring of the flap can minimize these adverse events.¹⁰ Prior abdominal surgery is usually not a contraindication to performing a DIEP flap unless there is a paramedian incision that has violated the system of deep perforators.¹¹ Midline abdominal incisions often facilitate the performance of bilateral DIEP flaps but may limit the amount of available tissue for unilateral DIEP flaps. Patients with elevated body mass index (BMI 30–35) are usually good candidates for this flap; however, when BMI exceeds 35, adverse events such as seroma, infection, and delayed healing may increase.¹²

Advanced patient age (>65 years) is considered by some to be a relative contraindication for DIEP flaps. Active tobacco use is a relative contraindication and is typically associated with delayed healing of the mastectomy skin flaps as well as the abdominal donor site.¹³

Preoperative Evaluation and Special Considerations

Patient selection includes a thorough history and physical examination, review of the reconstructive options, an understanding of patient expectations, and surgeon recommendations.^{2,3} Important details of the physical examination include body weight, patient height, body mass index (BMI), and estimated breast volume. Given the variation in breast size and body habitus, an understanding of symmetry following the first operation or subsequent operations is determined. The abdomen is the preferred donor site for most surgeons and patients and the DIEP flap is usually the best option. The most important physical finding related to the abdomen is a sufficient quantity of skin and fat to reconstruct the desired breast volume. Most women have

experienced childbirth and have an excess of abdominal skin and fat. Although a woman may be slender, with a paucity of abdominal fat, she may still be a candidate for a DIEP flap if the reconstructive requirements are low. In women who are overweight or obese, a DIEP or free TRAM flap may be considered; however, the flap must be tailored to sustain adequate perfusion throughout to minimize the incidence of fat necrosis.

The decision as to whether to use a perforator flap or a musculocutaneous flap can be difficult. The author's original algorithm was based on breast volume, abdominal fat volume, perforator diameter, number of perforators, patient age, tobacco use, and whether the reconstruction is unilateral or bilateral. In general, a DIEP flap is performed when the volume requirement is less than 1000 cc and the patient has mild to moderate abdominal lipodystrophy. A muscle-sparing free TRAM flap is usually performed when the volume requirement exceeded 1000 cc or if the patient has severe abdominal lipodystrophy (Table 3.1). The author's indications for a pedicle TRAM and superficial inferior epigastric artery perforator flap are also included. In this author's practice, the DIEP flap constitutes approximately 70% of all abdominal flaps followed by the muscle-sparing (MS-2) free TRAM (Fig. 3.1).

TABLE 3.1 An Algorithm for Selection of a Free TRAM, DIEP, SIEA or Pedicle TRAM Flap

Factor	Pedicle TRAM	Free TRAM	DIEP	SIEA
Breast Volume Requirement				
<1000 g	Yes	Yes	Yes	Yes
>1000 g	Yes with delay	Yes	Maybe	No
Quantity of Abdominal Fat				
Mild to moderate	Yes	Yes	Yes	Yes
Severe	Yes with delay	Yes	Maybe	Maybe
Perforators				
None	Yes	Yes	No	No
One	Yes	Yes	Yes	Yes
Two or more	Yes	Yes	Yes	Yes

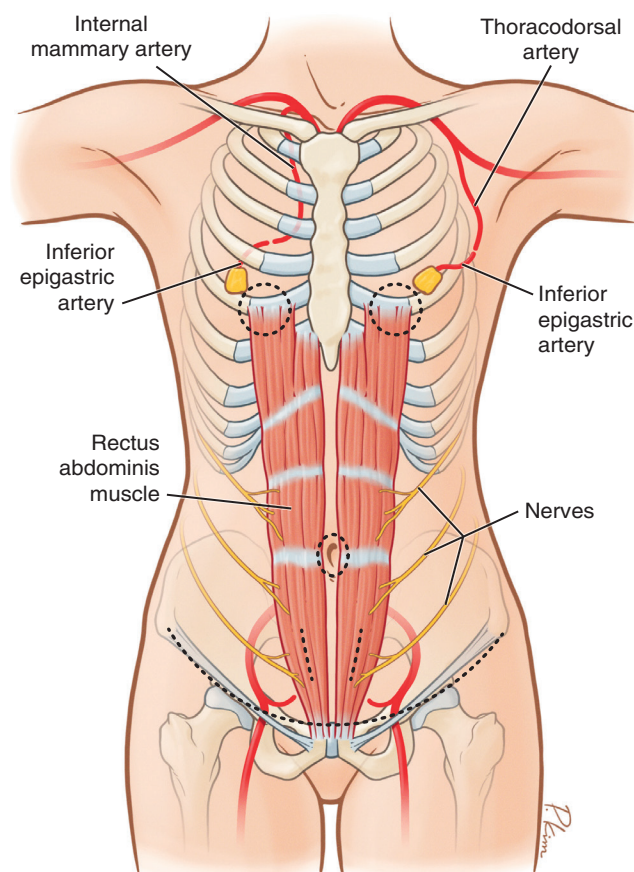
TABLE 3.2 The Four Modalities for Preoperative Imaging of the Perforators

Test	XR	Contrast	Caliber	Location	Flow	Course	Accuracy
Doppler	No	No	No	Yes	No	No	Low
Color duplex	No	No	No	Yes	Yes	No	Moderate
CTA	Yes	Yes	Yes	Yes	No	Yes	High
MRA	No	Yes	Yes	Yes	No	Yes	High

CTA, computerized tomographic angiography; MRA, magnetic resonance angiography.

Preoperative Imaging

With the introduction of perforator flaps, preoperative imaging has proved to be useful to identify the location and caliber of the perforating vessels.^{6-9,14} Preoperative imaging enables surgeons to identify suitable perforators and to determine the patency of primary source vessels, namely the inferior epigastric and internal mammary vessels. There are several modalities that are currently available, which include Doppler and color duplex ultrasound, CTA, and MRA (Table 3.2). One study shows that paramedian incisions invoked the most damage to the vascular supply, negatively impacting the perforators, superficial inferior epigastric

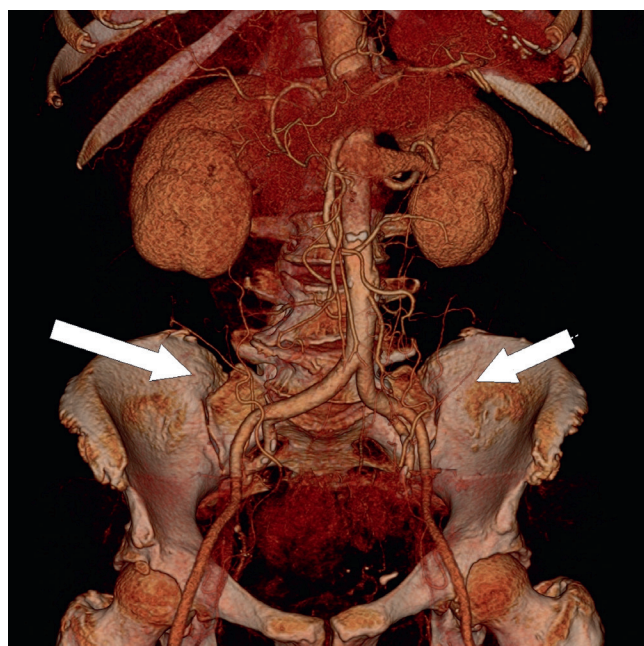


• **Fig. 3.1** Schematic illustration demonstrating the abdominal markings, rectus abdominis muscles, innervation, and recipient vessel options.

TABLE 3.3 The Various Abdominal Incisions and Their Consequences on the SIEA, DIEA, and Abdominal Perforators¹¹

Scar	N	SIEA Disruption	DIEA Disruption	Perforator Disruption
Laparoscopy	20	None	None	None
Open appendectomy	20	All (ipsilateral)	None (ipsilateral)	Medial row of DIEA
Pfannenstiel	35	Medial branch (30/35)	None	NR
Paramedian	3	All (ipsilateral)	All (ipsilateral)	All (ipsilateral)
Open choly	1	None	None	None
Midline	17	None	None	Crossover

Choly, cholecystectomy; NR, not reported.



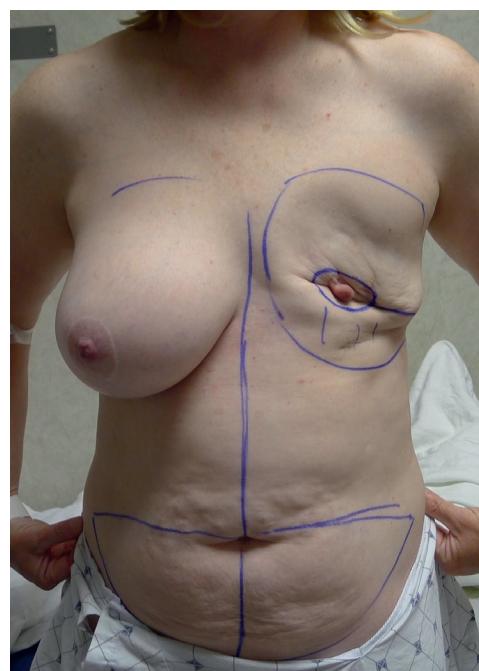
• **Fig. 3.2** Preoperative CT angiogram of the deep inferior epigastric artery. The arrows depict the general location of the origin of the deep inferior epigastric artery and vein.

artery (SIEA), and deep inferior epigastric artery (DIEA). On the contrary, laparoscopic incisions invoked the least damage (Table 3.3).

Surgical Technique

Selection of Perforator for DIEP Dissection

When considering the DIEP flap, many surgeons will assess of the vascular anatomy using the methods described above (Fig. 3.2). Intraoperative assessment is equally effective in identifying the abdominal wall perforating vessels. Reliance solely on intraoperative assessment requires more experience because of the variability associated with perforator location, caliber, and number. There are 5 types of perforators that are typically encountered.¹⁵ These perforators are direct (no muscle perforation, e.g. SIEA) and indirect (muscle perforation). In general, for a perforator flap to



• **Fig. 3.3** Preoperative patient markings in preparation for a DIEP flap.

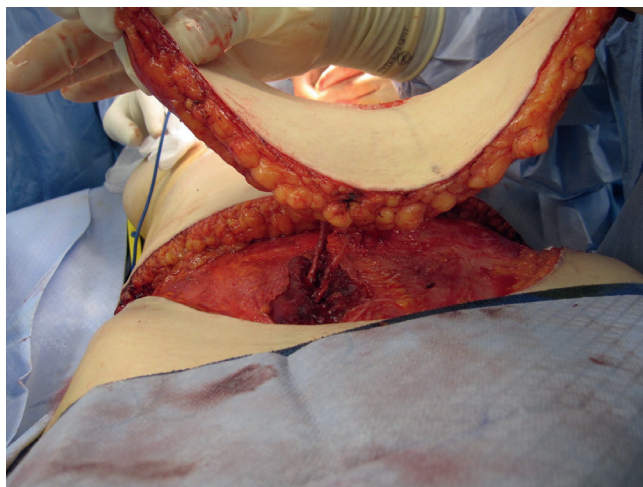
be successfully harvested and transferred, a single perforating artery and vein of at least 1.5 mm in diameter with a palpable pulse is recommended, although not absolute. If a dominant perforator arising from the deep system is not identified, one can consider performing an SIEA flap or a muscle-sparing free TRAM that incorporates several arterial and venous perforators.

Operative Technique – DIEP Flap Harvest

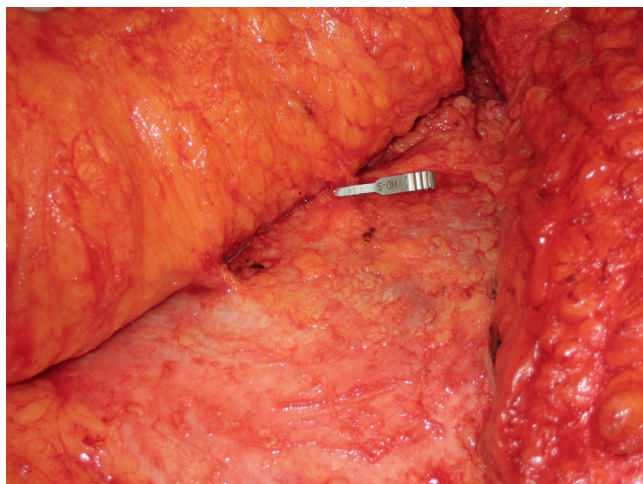
The preoperative markings are made with the patient standing and include the anterior superior iliac spine as well as the upper and lower transverse proposed incisions (Fig. 3.3). In the operating room, patients are placed in the supine position under general anesthesia with the arms abducted to 75 degrees. A Foley catheter is inserted, pneumatic compression devices are applied to both lower extremities and the appropriate medications are administered (antibiotics,

chemoprophylaxis). The upper abdominal incision is created first and the suprafascial adipocutaneous layer is elevated towards the xiphoid process. The patient is flexed at the waist approximately 30 degrees to determine the level of the inferior abdominal incision. The umbilicus is incised at its periphery and dissected along its stalk to the anterior rectus sheath. In the case of a bilateral reconstruction, the midline is divided along the linea alba.

Following the initial incisions, the right and left hemi-abdomen is elevated from a lateral to medial direction. The selected perforator should ideally be located near the center of the flap in order to obtain equidistant perfusion (Fig. 3.4). Perforator diameter should be 1.5 mm or greater and have a palpable pulse. When several perforators are available, sequential occlusion can be performed to assist with the selection process (Fig. 3.5). If preoperative angiography was performed, the dissection can proceed immediately to the predetermined dominant perforator. Multiple perforators can be considered when they are aligned in series or in close proximity (Fig. 3.6). Medial row perforators are preferred

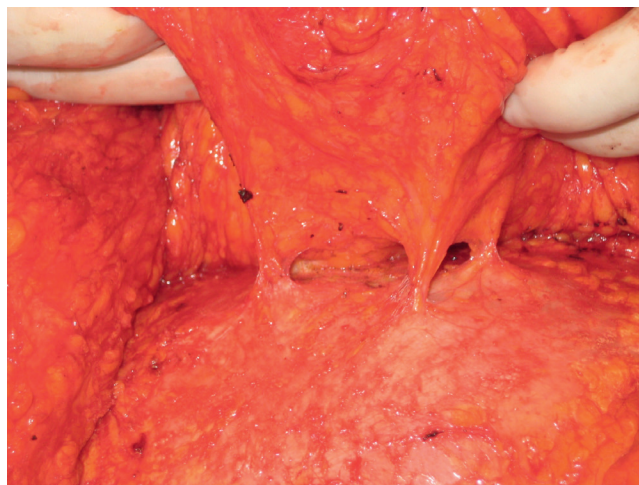


• **Fig. 3.4** The right and left flaps are initially elevated in a lateral to medial direction.



• **Fig. 3.5** Intraoperative sequential occlusion of perforators can assist with determining the optimal perforator.

when the flap will include zone III or zone IV. Lateral row perforators can be considered; however, dissection of these perforators can be associated with an increased incidence of motor nerve injury due to proximity.¹⁶ When initiating the perforator dissection, including a small cuff of the anterior rectus sheath (1–2 mm) around the perforator is sometimes recommended, especially if the perforator is piercing the anterior rectus sheath at a tendinous inscription. During the dissection it is important to preserve the lateral intercostal nerves as they pierce the rectus abdominis muscle at the junction of the lateral and central longitudinal segments to avoid denervation injury (Fig. 3.7). Intramuscular motor nerve branches that cross the perforator or the source vessel can be sharply divided (Fig. 3.8). Whether or not to coapt the severed nerve is controversial. Some advocate using a



• **Fig. 3.6** Several perforators are often isolated prior to selecting the optimal perforator or perforators.

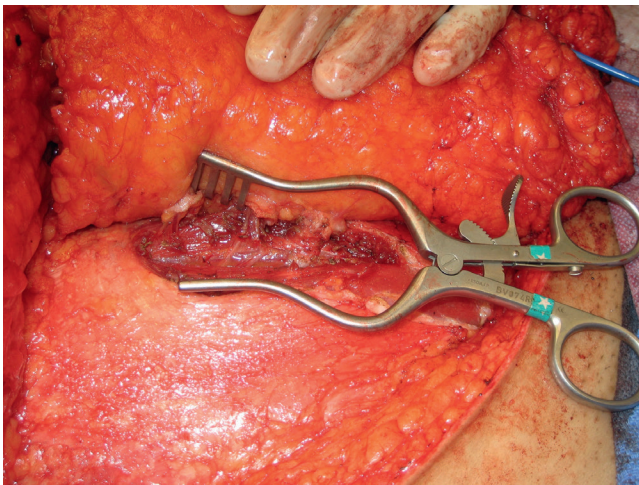


• **Fig. 3.7** The lateral innervation to the rectus abdominis muscle is preserved.

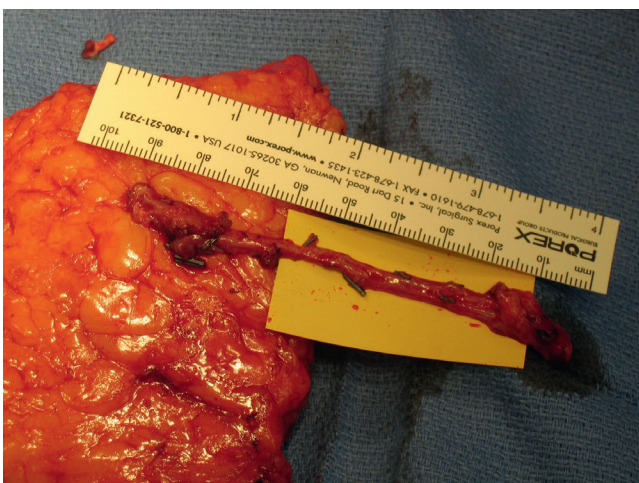
micro-suture for coaptation; however, others prefer not to coapt but rather allow the transected nerve to neurotize into the adjacent muscle.

The desired length of the vascular pedicle is dependent on surgeon preference. Some surgeons are content with a 5–6-cm pedicle and others prefer a 10–12-cm pedicle length (Fig. 3.9). In either case, the intramuscular dissection proceeds to the point that the perforator or inferior epigastric vessel becomes submuscular. If additional length is desired, the dissection progresses from the lateral edge of the muscle towards the iliac vessels. It is the author's preference to continue the dissection until the vessel diameter approaches 2.5–3 mm.

When a unilateral reconstruction is planned, preservation of the contralateral perforators is recommended as a “lifeboat” in the event of perforator injury. When a bilateral reconstruction is planned, it is advised to proceed cautiously when isolating and dissecting the perforators because a contralateral lifeboat will not be available. When in doubt about the quality of the perforators, a muscle-sparing free TRAM flap is considered.



• **Fig. 3.8** The motor branches are sometimes divided when crossing over the primary source vessel.



• **Fig. 3.9** A DIEP flap is harvested with a 9-cm vascular pedicle.

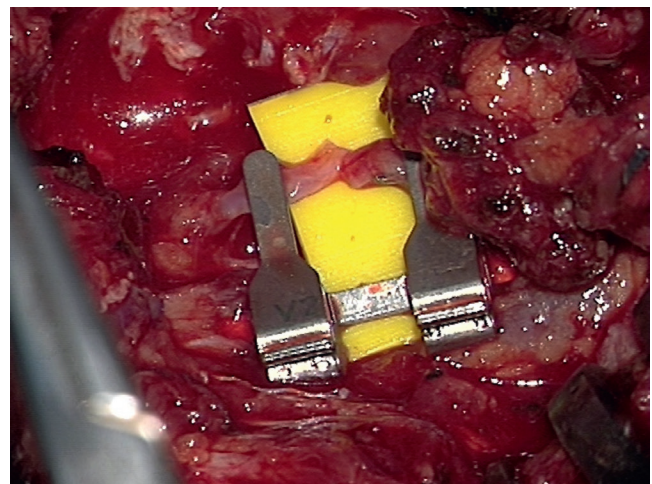
Operative Technique – Recipient Vessels

Integral to the selection of the flap for microvascular reconstruction is the selection of the recipient vessels. The recipient vessels typically include the internal mammary or the thoracodorsal artery and vein.¹⁷ The internal mammary vessels have become the vessels of choice in most cases because of ease of exposure, compatible size match, maximum freedom for flap positioning, and excellent flow characteristics. The diameter of the internal mammary vessels at the level of the fourth rib ranges from 0.99 to 2.55 mm for the artery and 0.64 to 4.45 mm for the vein. In contrast, the diameter of the thoracodorsal vessels ranges from 1.5 to 3.0 mm for the artery and 2.5 to 4.5 mm for the vein.

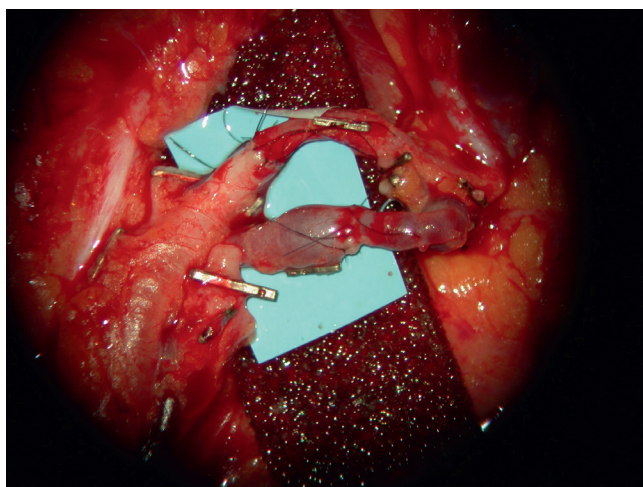
In the author's practice, the internal mammary vessels are preferred for the majority of DIEP flaps. The vessels are exposed at either the 3rd or 4th interspace and may involve excision of the cartilaginous segment or by dissecting between the cartilaginous segments without cartilage excision. This portion of the operation is usually performed using loupe magnification. The thoracodorsal artery and vein are considered in the setting of a modified radical mastectomy where the thoracodorsal vessels have been exposed.

Operative Technique – Microsurgical Anastomosis

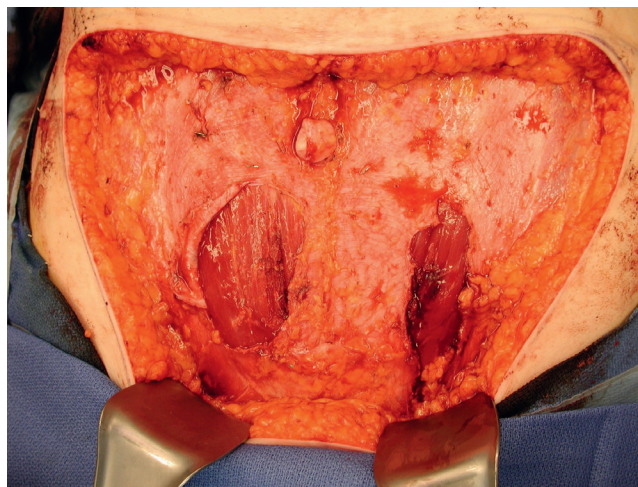
Intravenous heparin is usually administered prior to division of the inferior epigastric vessels. The harvested flap is positioned over the chest wall and the inferior epigastric artery and vein are aligned with the internal mammary artery and vein (Fig. 3.10). The anastomosis can be hand sewn or coupled and based on surgeon preference. The author's preference is to hand sew both the artery and vein using 8-0 or 9-0 sutures in an interrupted or continuous fashion (Fig. 3.11).



• **Fig. 3.10** The internal mammary artery and vein are prepared as recipient vessels for the microvascular anastomosis.



• **Fig. 3.11** A completed hand-sewn arterial and venous anastomosis is demonstrated.



• **Fig. 3.13** Typical appearance of the abdomen and rectus abdominis muscles following bilateral DIEP flap harvest.



• **Fig. 3.12** A de-epithelialized DIEP flap is positioned on the chest wall prior to inset.

Flap Insetting

Following completion of the vascular anastomoses, the pedicle is draped over the chest wall to prevent twisting and kinking. Proper flap positioning is important to recreate the breast contour and shape. For optimal inseting, it is recommended to sit the patient upright at 45 degrees to assess the position, symmetry, contour, and projection of the breast. The medial edge of the flap is usually positioned along the sternal border and the lateral aspect of the flap is positioned on the lateral chest wall. Flap fixation to the chest wall is sometimes necessary to prevent flap displacement. These sutures are placed superomedially, inferomedially, and laterally.

In cases of a skin-sparing mastectomy, the skin territory to be exteriorized is delineated and the remainder of the flap is de-epithelialized (Fig. 3.12). When a nipple-sparing mastectomy has been performed, a Doppler is used to identify an arteriovenous signal and delineated with a 2-cm circle. The remainder of the flap is de-epithelialized and the skin paddle is exteriorized. With delayed reconstruction, the

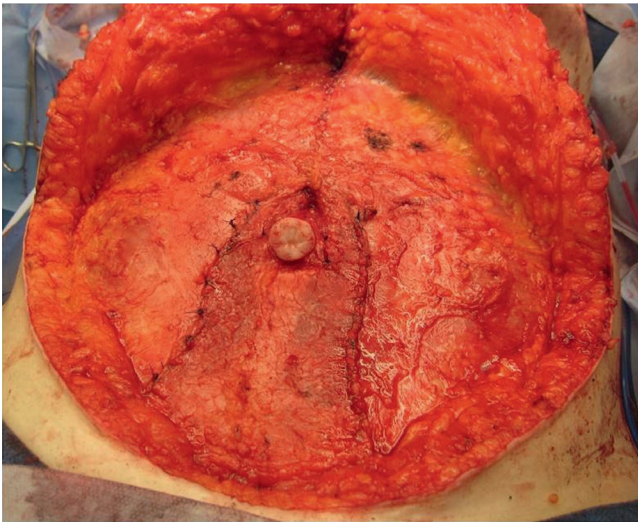
lower mastectomy skin is usually excised and the inferior edge of the autologous flap is used to recreate the inframammary fold.

With a unilateral reconstruction, it is important to achieve symmetry with the opposite breast that is used as a template for the reconstruction. The flap can be folded in a conical fashion or it can be folded laterally such that apical portion (zone II) of the flap is tucked under zone I with zone III of the flap being positioned along the sternal border. In bilateral cases, symmetry is more readily achieved because both breasts are shaped and inset in the same manner.

Abdominal Closure

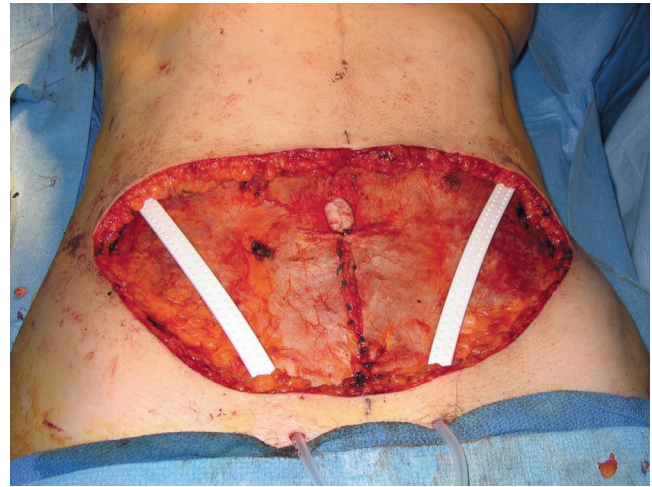
Abdominal closure is an important component of DIEP flap reconstruction. It is important to approximate the medial and lateral segments of muscle following DIEP flap harvest (Fig. 3.13). This will usually prevent lateralization of the rectus muscle as intra-abdominal pressure increases. Closure of the anterior rectus sheath is completed using an absorbable or non-absorbable monofilament suture placed in an interrupted figure-of-eight fashion. All lamellae of the anterior sheath are closed to ensure stability. A second row of sutures is typically placed in a running, continuous fashion for further reinforcement (Fig. 3.14). The use of a mesh for fascial reinforcement is rarely necessary following DIEP flap harvest; however, if the anterior rectus sheath is friable, mesh reinforcement can be considered.

Following fascial closure, plication of the remaining fascia is sometimes necessary to achieve ideal contour. With unilateral reconstructions, contralateral plication will serve to achieve uniformity of the anterior abdominal wall and to centralize the umbilicus. With bilateral reconstructions, the supraumbilical fascia is often plicated along the midline to prevent an upper abdominal bulge. These sutures are usually monofilament and placed in a figure-of-eight fashion. Infraumbilical midline sutures are also sometimes useful to achieve ideal contour.



• **Fig. 3.14** Typical appearance of the abdomen following closure of the anterior rectus sheath incisions.

Skin closure is the final stage of abdominal closure and includes the umbilicus and the incisions. Two closed suction drains are always used to minimize the occurrence of a fluid collection (**Fig. 3.15**). The injection of liposomal bupivacaine is often considered to reduce postoperative pain.¹⁸ Skin closure is performed in three layers that include Scarpa's fascia, dermis, and epidermis. Monofilament sutures are



• **Fig. 3.15** Two closed suction drains are inserted prior to abdominal closure.

used for the dermis and subcuticular layers. Lateral dog-ears should be identified at time of closure and addressed. This will lead to lengthening of the abdominal incision but an improvement in abdominal contour. The inseting of the umbilicus is another important step to achieve ideal abdominal aesthetics. Various skin incision patterns are possible that include circular, oval, and “U” designs, all of which are capable of delivering good results.

Case Examples

CASE 3.1

A 48-year-old woman with stage 2B left breast cancer underwent unilateral skin-sparing mastectomy without immediate reconstruction followed by postoperative chemotherapy and radiation therapy (**Case 3.1.1**). Delayed reconstruction 1.5 years later with a two-perforator DIEP flap was performed without incident (**Case 3.1.2**). Postoperatively, the patient had an upper pole contour abnormality and desired increased projection and volume. Secondary fat grafting to the upper pole and to the flap was planned (**Case 3.1.3**). Two-year follow-up following two rounds of fat grafting (125 cc and 85 cc) was performed demonstrating excellent volume and contour symmetry (**Case 3.1.4**).



• **Case 3.1.1**

CASE 3.1—cont'd



• Case 3.1.2



• Case 3.1.3



• Case 3.1.4

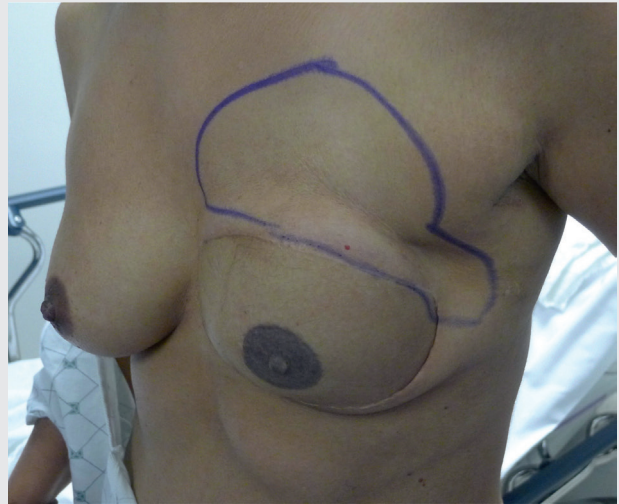
CASE 3.2

A 42-year-old with stage 1 left breast cancer opted for bilateral skin-sparing mastectomy and immediate reconstruction with DIEP flaps. [Case 3.2.1](#) shows her preoperative appearance. A single perforator DIEP flap was harvested bilaterally. The internal mammary artery and vein were used for the anastomosis. Chemotherapy and radiation therapy were not

performed. Postoperatively, the patient did well but desired increased breast projection ([Case 3.2.2](#)). Smooth, round saline implants were placed under the pectoralis major muscle bilaterally and filled to 100 cc ([Case 3.2.3](#)). Five-year follow-up demonstrates excellent volume and contour symmetry ([Case 3.2.4](#)).



• Case 3.2.1



• Case 3.2.3



• Case 3.2.2



• Case 3.2.4

CASE 3.3

A 45-year-old woman who was *BRCA1* positive (Case 3.3.1) opted for bilateral prophylactic nipple-sparing mastectomy via a lateral and infra-areolar incisional approach. Immediate reconstruction with bilateral DIEP flaps was performed. Flap monitoring using a handheld Doppler was performed using an exteriorized skin paddle along the lateral incision.

Postoperatively, she did well and desired improved upper pole contour. Secondary revision included fat grafting to the upper pole, burying the exposed skin paddle, and liposuction of the lateral excess (Case 3.3.2). Two-year follow-up demonstrated excellent volume and contour symmetry (Case 3.3.3)



• Case 3.3.1



• Case 3.3.2

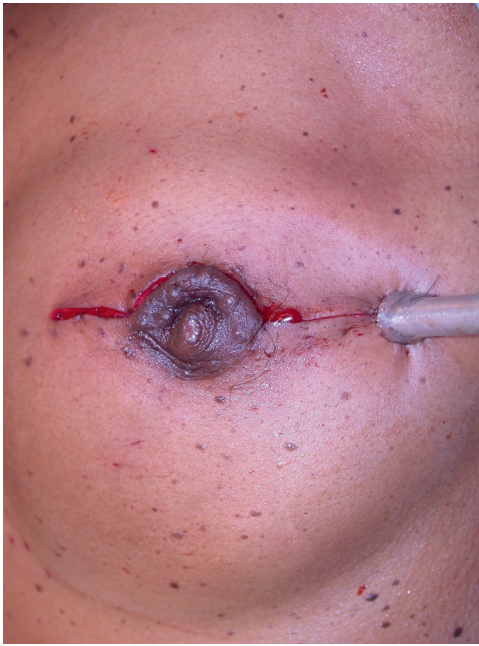


• Case 3.3.3

Postoperative Care and Expected Outcomes

Immediately following DIEP flap reconstruction, patients are transferred to a monitoring unit. Patients are positioned in bed with the head at 30 degrees to minimize the stress

placed on the abdominal closure. They are also instructed to ambulate slightly flexed at the waist for a few days until the skin elasticity improves. Pain management strategies include patient-controlled analgesics and enhanced recovery after surgery (ERAS) protocols.¹⁹ Patients are typically instructed to ambulate on postoperative day (POD) 1 and



• **Fig. 3.16** The handheld Doppler is used for monitoring the arterial and venous signals.

encouraged to sit in a chair. Most patients are discharged home on POD 3; however, prolonged hospitalization is sometimes necessary when adverse events occur.

Postoperative flap monitoring is a critical component and predictor of successful flap outcomes. Traditional methods of flap monitoring have included handheld Doppler probes, surface temperature assessment, flap turgor, capillary refill, and flap color (Fig. 3.16). Flaps are assessed and described as warm and soft with good capillary refill. This demonstrates that there is good inflow and outflow within the flap. With inflow problems, the flap will become pale, cool, and soft with delayed or absent capillary refill. With venous outflow problems the flap will become tense, congested, purple, with brisk capillary refill. Although these methods of flap monitoring are usually effective, they are not continuous, subject to interpretation, and dependent on clinical personnel.

In an early study comparing the DIEP flap to the muscle-sparing free TRAM, Nahabedian et al. demonstrated improved outcomes with regard to abdominal contour and strength following DIEP flap reconstruction.^{3,20} In unilateral cases, an abdominal bulge occurred in 4.6% and 1.5% of women following free TRAM and DIEP flap reconstruction, respectively. The ability to perform sit-ups was demonstrated in 97% and 100% following free TRAM and DIEP flaps, respectively. Following bilateral reconstruction, the differences were more pronounced. An abdominal bulge occurred in 21% and 4.5% following free TRAM and DIEP flaps, respectively. The ability to perform sit-ups was 83% and 95% following free TRAM and DIEP flaps, respectively.



• **Fig. 3.17** A DIEP flap that is severely congested due to venous occlusion.

Management of Complications

When alterations in DIEP flap perfusion occur, the patient is prepared for operative exploration. These alterations in flow may be venous or arterial in origin and typically manifest as flap venous congestion (tense, mottled, purple) or arterial occlusion (soft, pale, ashen) (Fig. 3.17). In the operating room, the flap is exteriorized and the anastomosis is evaluated. Intraoperative salvage maneuvers include but are not limited to assessing kinks or twisting of the pedicle, redoing the vascular anastomosis, use of a Fogarty embolectomy catheter to remove intraluminal thrombus, and intra-arterial injection of fibrinolytic agents. Postoperatively, the use of medicinal leeches placed on the surface of a mildly congested flap can be beneficial when venous outflow is sluggish. Leeches, however, are not a substitute for operative exploration when indicated.

Other complications include but are not limited to infection, hematoma, seroma, fat necrosis, partial flap necrosis, and total flap necrosis.²¹ Most patients are placed on antibiotics postoperatively; however in the event of cellulitis or abscess formation, prolonged antibiotics or surgical drainage is considered (Fig. 3.18). Fluid collections can be managed conservatively or aggressively depending on the degree and acuity. Small collections may be observed; however, expanding hematomas or intractable seromas usually require operative correction. Partial and total flap necrosis will require operative debridement and secondary corrective procedures. Fat necrosis may be observed if small (<3 cm) but often excised if large (>3 cm).

Secondary Procedures

Secondary procedures following DIEP flap reconstruction are sometimes necessary and more often because the patient desires improvement related to volume, contour, position and symmetry.²² Secondary procedures of the breast typically include soft tissue revision to improve the contour and to reduce the volume when the flap is considered too



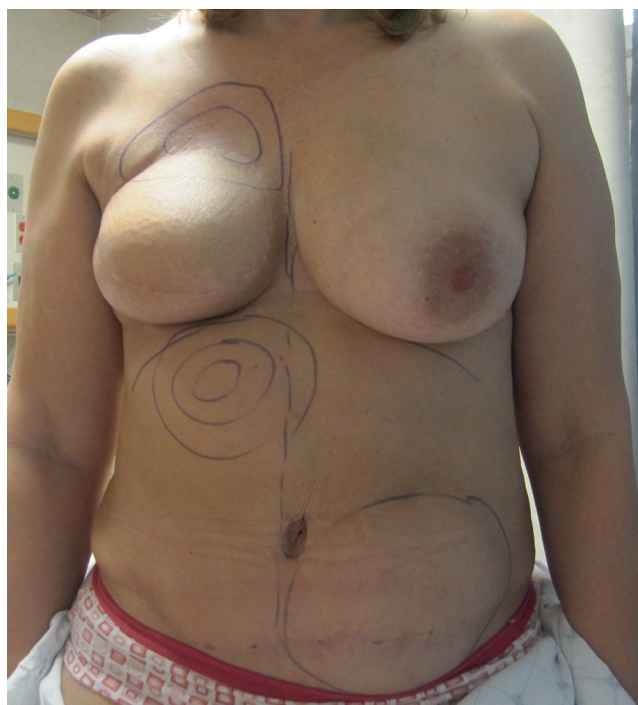
• **Fig. 3.18** Cellulitis following DIEP flap reconstruction.



• **Fig. 3.19** The technique of fat grafting following DIEP flap reconstruction is illustrated.

large. This usually involves wedge excision of excess skin and fat. In situations where the DIEP flap lacks volume or projection, the use of autologous fat grafting has been demonstrated to be safe and effective. Fat grafting is most often used to improve contour abnormalities in the upper pole of the breast and also to improve the quality of the soft tissue following radiation therapy (Fig. 3.19). The use of implants placed under the DIEP flap is also useful to improve the volume and projection of the flap. Nipple reconstruction or tattooing is usually the final step in the reconstructive process.

Regarding the abdominal wall, secondary operations following DIEP flap reconstruction are occasionally necessary.^{19,23} Some of these revisions are necessary and others are not. Lower abdominal bulge is the most common necessary indication and revision is performed in approximately 5% of patients having DIEP flaps (Figs. 3.20 & 3.21). Dog-ear scars are the most common elective indication and revision is performed in <10% of patients. Neuromas of the anterior



• **Fig. 3.20** Preoperative photograph of a woman with a lower abdominal bulge following DIEP flap reconstruction.



• **Fig. 3.21** Postoperative photograph following repair of the bulge via plication and synthetic mesh reinforcement.

abdominal wall are rare (<1%) and usually require operative correction.

Conclusions

The DIEP flap is now the most common autologous option for women seeking autologous reconstruction following

mastectomy. The ability to transfer an adipocutaneous flap without removal of the rectus abdominis muscle has been the driving force. Many women are aware of the DIEP flap and seek surgeons who perform it. The preoperative, intraoperative, and postoperative factors that can influence the success of the DIEP flap have been outlined in this chapter.

PEARLS FOR SUCCESS

- In general, a DIEP flap is performed when the volume requirement is less than 1000 cc and the patient has mild to moderate excess abdominal fat.
- Preoperative imaging enables surgeons to identify suitable perforators and to determine the patency of primary source vessels, namely the inferior epigastric and internal mammary vessels.
- The internal mammary vessels are the vessels of choice in most cases because of ease of exposure, compatible size match, maximum freedom for flap positioning, and excellent flow characteristics.
- It is important to preserve the lateral intercostal motor innervation to maintain function of the rectus abdominis muscle.
- The selected DIEP flap perforator should be located near the center of the flap in order to obtain equidistant perfusion.
- Appropriate fascial closure is important to minimize the risk of a bulge or contour abnormality. Mesh materials are sometimes necessary.
- Postoperative flap monitoring is a critical component of the operation and performed using clinical assessment, Doppler signals, and near infrared spectroscopy.
- Early return to the operating room in the event of flap compromise is critical. Maneuvers include redoing the anastomoses, Fogarty catheter embolectomy, and thrombolytic agents.

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4

Free SIEA Flap Breast Reconstruction

KENNETH L. FAN, OLIVIA A. ABBATE AND DAVID H. SONG

Introduction

The superficial inferior epigastric artery (SIEA) flap relies on its namesake vessels to perfuse the ipsilateral abdomen skin and fat, generally for autologous breast reconstruction. This type A fasciocutaneous flap was described in 1971 for head and neck reconstruction by Antia and Buch. Grotting introduced the SIEA for use in breast reconstruction in 1991.¹ The advantage of this flap is the lack of fascial and muscular dissection. The SIEA sits in a suprafascial plane, eliminating the kind of donor morbidity seen in the deep inferior epigastric artery perforator (DIEP) or the muscle-sparing transverse abdominis muscle (MS-TRAM) flap.

Despite this, the SIEA flap failed to gain widespread acceptance due to difficulties in harvest and inset, vessel inconsistencies, decreased pedicle size and length, and tendency towards spasm.^{1,2} Historical high rates of take backs (14%–21%), arterial thrombosis (17.4%), short pedicle length, and flap failure (7%–14%) have led some to disavow this flap completely.³ As such, flaps based on the deep inferior epigastric artery (DIEA) have become the gold standard in autologous-based breast reconstruction.

With the refinement of microsurgical technique and understanding of the SIEA anatomy, the SIEA flap has enjoyed a resurgence, allowing surgeons to take advantage of the inherent donor-site advantages of this flap and the lack of fascial disturbance. Seminal cadaveric work by Taylor and Daniels traditionally indicated that the vessels are present in 65% of patients.⁴ Nahai demonstrated in a series of 27 successful SIEA flaps that the vessels are absent in as few as 13%.⁵ The senior author described a series of 145 SIEA flaps with a 6% take-back rate and a loss rate of 4.8%, comparable with other breast free flaps.² In this series, 500 abdominal-based breast free flaps were performed, 29% of which were SIEA flaps. Accordingly, when anatomically appropriate, the SIEA flap has become a mainstay in our practice and represents about 30% of our flap reconstruction volume, similar to other experienced microsurgeons.⁶ In this chapter, we will demonstrate how a SIEA flap can be selected and performed safely, and our strategies to increase success are also delineated in detail.

Indications and Contraindications

The SIEA flap shares the same indications as its DIEP or MS-TRAM counterparts. The vast majority of these cases are performed in breast reconstruction after mastectomy. Other indications include reconstruction in Poland syndrome, unsatisfactory implant reconstruction, or loss of volume after lumpectomy. Other applications, such as use in the head and neck, have been described and are beyond the scope of this chapter.

Our algorithm for superficial inferior epigastric (SIE) vessel selection is based intraoperatively and is as follows:

1. Venous size of 1.5 mm
2. Palpable arterial pulse
3. Pedicle length at least twice the flap size for inset (Please see Surgical Technique section for detail.)

Relative contraindications to the SIEA flap include prior abdominoplasty, Pfannenstiel incision, or liposuction. Liposuction cannulas can damage the fragile SIEA vessels easily due to their suprafascial nature. In the setting of prior abdominal surgery, careful intraoperative assessment of the SIE vessels is crucial. Successful harvest can be achieved if they are not damaged (see [Case 4.1](#)).

Other relative contraindications include inadequate flap volume and the lack of an IMA recipient vessel. The use of the SIEA in the unilateral reconstruction is limited due to its ability to only supply a hemiabdomen. If a patient still desires the decreased donor morbidity of an SIEA flap and requires volume, stacking flaps for unilateral reconstruction or discussion of multiple rounds of fat grafting may be required. The SIEA provides 4–7 cm of pedicle length. Due to this shorter length, thoracodorsals or thoracoacromials are generally not used as recipient vessels.

Preoperative Evaluation and Special Considerations

In preparation for surgery, a detailed history and physical examination are performed. It is of utmost importance to obtain a history of prior surgeries, medications, familial

diseases and nicotine usage. Most flap patients are generally healthy. Mastectomy and autologous reconstruction may be their first major surgery and stress on their bodies. However, active cancer, use of oral contraceptives, long surgical times, decreased venous return after abdominal plication, and family history of clotting disorders all increase the risk of deep venous thrombosis (DVT) and subsequent pulmonary embolism. The Caprini Risk Assessment score is routinely calculated and documented in the patient's preoperative chart.

Physical examination entails examining for prior surgical scars and availability of abdominal tissue. High abdomen scars, such as the Kocher, do not preclude the possibility of abdominal-based flaps. Full disclosure of the possible donor-site wound healing complications is necessary. Abdominal tissue excess may be assessed by pinching the infraumbilical skin and fat or performing the classic Diver's test.

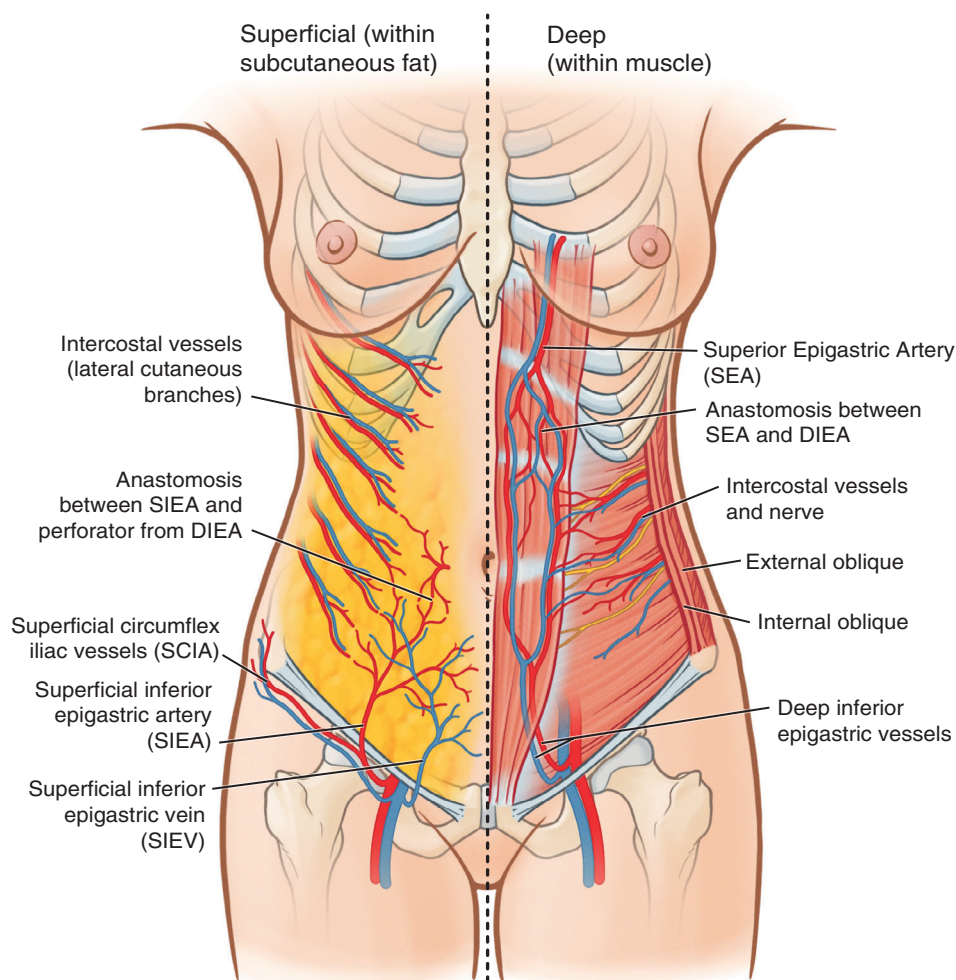
While we do not routinely do so, computer tomography angiography (CTA) from the diaphragm to the lesser trochanter can be used for preoperative assessment of

vasculature including the SIE vessels prior to free transfer. Generally, SIEA size is measured at the inguinal ligament; DIEP vessels are measured at the take off of the external iliac artery. SIE vessels of adequate caliber for flap reconstructions are 1.5–2.3 mm on preoperative imaging. Despite this, only about half of vessels found adequate on CTA are usable after intraoperative assessment.⁷ Intraoperative assessment is still the gold standard.

Surgical Techniques

Relevant Anatomy

The SIEA originates 2–3 cm below the inguinal ligament: directly from the common femoral artery in 17%, as a shared branch with the superficial circumflex iliac artery (SCIA) in 48% of cases, and absent or hypoplastic in 35% of cases (Fig. 4.1). Recent cadaveric and imaging studies have reliably identified vessels in 65%–75% of cases.⁸ At its origin, the SIEA is generally 1.6 mm, compared to



• **Fig. 4.1** The SIEV arises 4–5 cm from midline and is more superficial to the SIEA. The SIEA arises 3 cm more laterally and generally deep to Scarpa's fascia at the abdominoplasty incision. It arises above the Scarpa's fascia when travelling cephalad, and anastomoses with the perforating arteries of the DIEA. (Reproduced from Neligan PC. Plastic Surgery. 4th ed. Vol 5. Oxford: Elsevier; 2017:324)

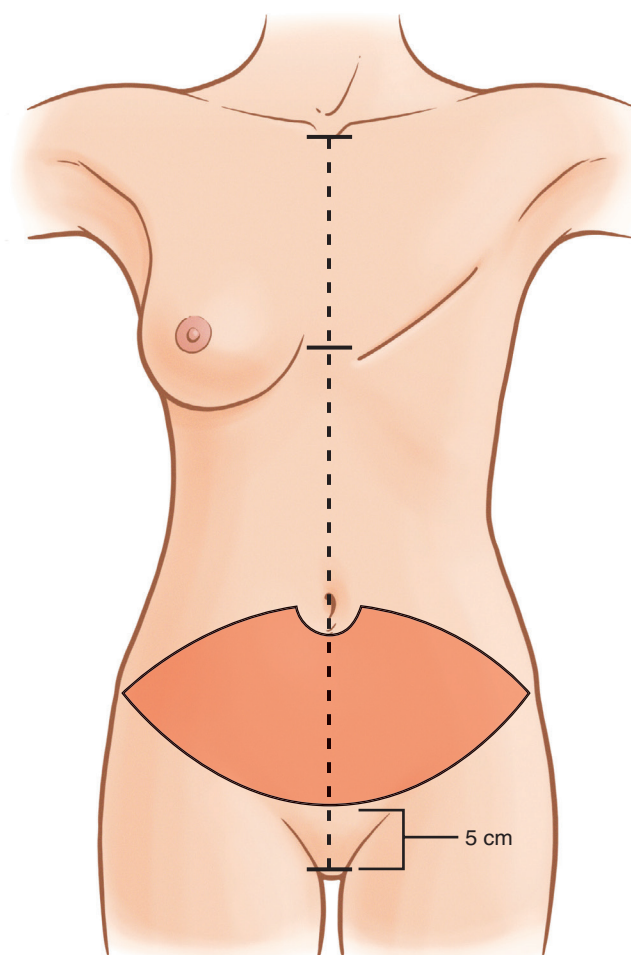
3.4 mm with the DIEA at the external iliac artery just proximal to the inguinal ligament. A general rule of thumb is that the SIEV arises in the junction between the medial and middle third of a line from the pubis symphysis to the anterior superior iliac spine (ASIS), approximately 4–5 cm from midline. The SIEA arises 3 cm more laterally, and deep to Scarpa's fascia.

After piercing the deep fascia, the artery travels deep to the cribriform fascia in the superolateral portion of the femoral triangle, piercing the fascia to cross the inguinal ligament at its midway point lying deep to Scarpa's fascia. Well above the inguinal ligament, the vessel penetrates Scarpa's fascia to lie in the superficial subcutaneous tissue. Here it runs superomedially toward the periumbilical region progressively more superficial to anastomose with the ipsilateral medial and lateral perforating arteries from the DIEA through the subdermal plexus. Probably due to its lateral nature, perfusion studies have indicated the SIEA acts similarly to lateral row DIEP vessels, without blood flow crossing the midline.⁹ In patients with adequate flow and size of the SIEA, the deep and superficial inferior epigastric systems share common vascular channels that can interchangeably supply the lower abdominal skin, providing the anatomical basis of the SIEA flap.

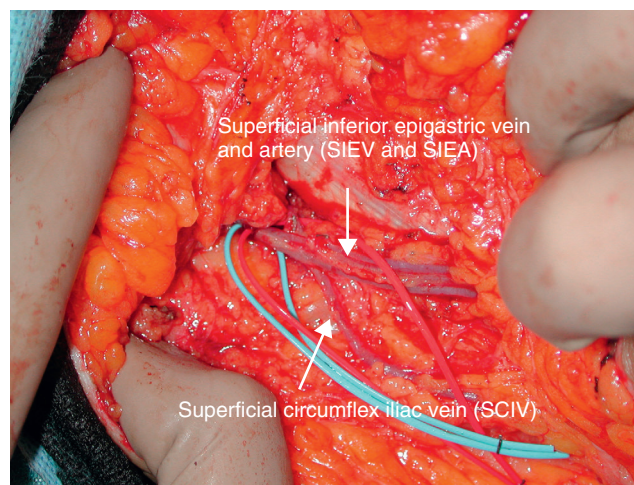
The SIEA often have two closely associated diminutive venous comitantes. These veins are small in caliber and are not often used. They may be used, however, if they are large enough compared to the superficial inferior epigastric vein (SIEV). The SIEV drains into the saphenofemoral bulb before meeting the femoral vein or into the greater saphenous vein as a tributary. Anastomotic ladder-like connections exist between this superficial system and perforating veins from the deep inferior epigastric veins (DIEVs). In the physiologic state, the SIEV has been shown to be the preferential drainage path of the abdominal pannus.⁹ In 40% of patients, medial and lateral branches of the SIEV drain variably into different vessels.¹⁰ Both branches, if present, need to be preserved and dissected for adequate venous drainage as many flaps lack overlapping venous territory drainage between branches. If a single venous anastomosis is preferred, functional testing for venous congestion is paramount.

Preoperative Markings

Markings are performed in the preoperative surgical area. The patient's midline is marked from the sternal notch to the pubic tubercle, including horizontal midline marks at the inframammary fold (Fig. 4.2). Our preoperative markings for all abdominal-based flaps are lower than the traditional DIEP flaps; we do not include the skin bridge immediately cephalad to the umbilicus. Instead we begin our incision half way at the level of and around the umbilicus. The caudal incision is approximately 5–6 cm above the pubis symphysis. The lower incision increases the chance of capturing the point when all the venae comitantes converge, thereby including the more lateral superficial circumflex iliac veins into the flap (Fig. 4.3).



• **Fig. 4.2** Markings of an SIEA flap. We make the superior and inferior incision lower to capture venous comitantes of the SIEA flap.

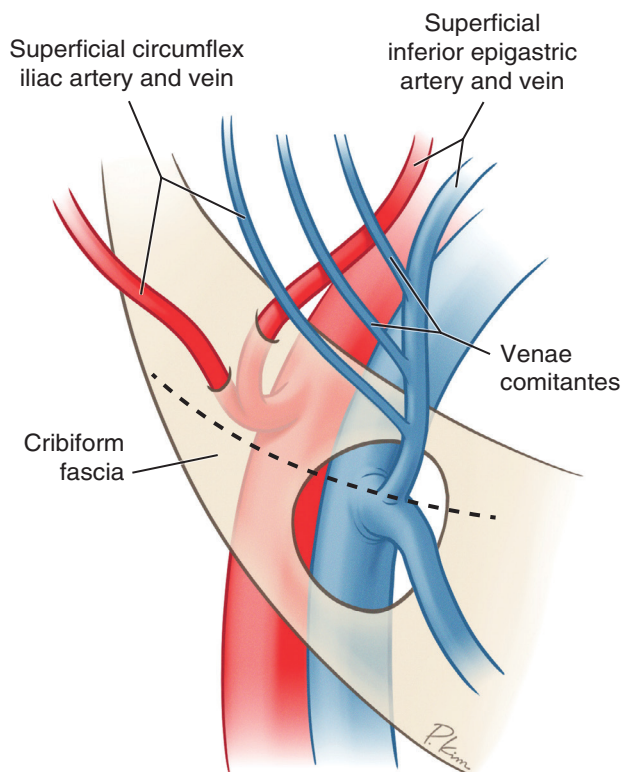


• **Fig. 4.3** We routinely include the superficial circumflex vein in dissection. It often joins with the superficial inferior epigastric vein as seen here.

This also allows us to visualize and effectively use the SIEA prior to it arborizing into smaller tributary arterioles. We mark this flap with this method in all abdominal-based breast reconstruction for this reason. Periumbilical perforators are preserved with careful technique.

Flap Dissection

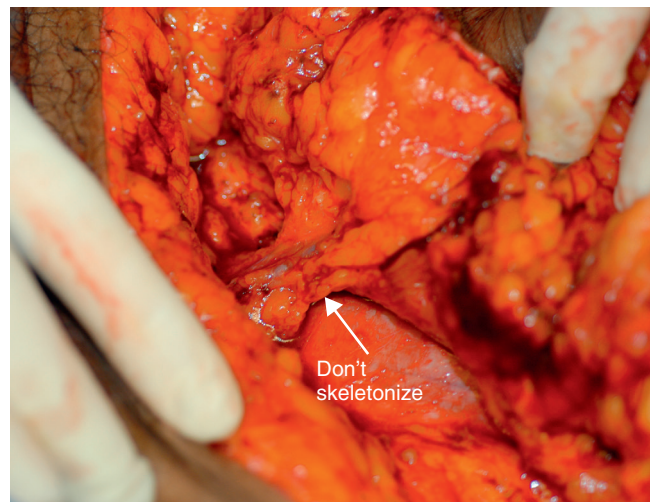
Dissection begins at the lower incision in the lateral to medial direction. This incision should be made judiciously, as in a thin patient the SIEV may lay superficial. Using loupe magnification dissection, the SCIA/SCIV is first encountered. The SCIV is included in the dissection to improve venous outflow whenever possible (see Fig. 4.3). The SIEA is next encountered at the midpoint of the inguinal ligament, generally deep to Scarpa's fascia. We avoid circumferential dissection as this can lead to arterial spasm. The SIEV is identified in a more medial and superficial position in the subcutaneous tissue 2–3 cm medial to the SIEA at a point 4–5 cm lateral from the midline. All branches of the SIEV are included and followed. The vessels are followed for a few centimeters by having an assistant provide gentle cephalad retraction of the flap and superior retraction of the groin skin. The SIEA is dissected in the inferomedial direction until the fascial hiatus is encountered. Fully opening the hiatus at the cribriform fascia affords for maximal exposure (Fig. 4.4).



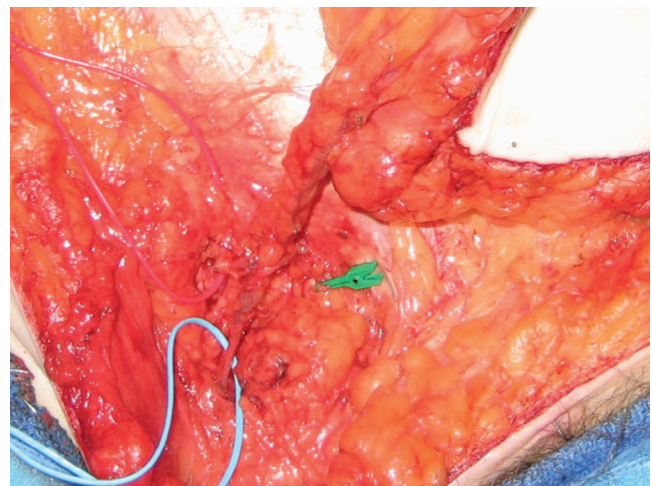
• **Fig. 4.4** Incision is made at the cribriform fascia to expose the arterial and venous take offs for maximal pedicle length.

The SIEA and SIEV are dissected to the level of the first appearing lymph node. The lymph node, as noted by Buchel et al., is frequently where the artery and vein separate.¹¹ Minimizing trauma to the lymphatic channel is key in this area to decrease seroma rates, commonly seen as high as 20% in SIEA flaps (3.4% in our series).¹² However, if nodes are within the bundle, it is counterproductive to attempt to skeletonize and extract this node (Fig. 4.5), as this leads to unnecessary risk, spasm, and possibly irreversible trauma. The artery at this level makes a sharp 90–150 degree turn toward the femoral artery.

The vein is also followed and will join other comitantes before entering the cribriform fascia. Further dissection at this point will identify the confluence of vessels between the SIEV, SCIV, and other venae comitantes at the saphenofemoral bulb (Fig. 4.6). This single dominant vein is usable for anastomosis providing excellent outflow for the



• **Fig. 4.5** Skeletonizing the vessels from interposing adherent lymphatics is counterproductive.



• **Fig. 4.6** Vessel dissection to the saphenofemoral bulb. Artery tagged in red, vein in blue.

flap. Some authors have cited this bulb to be too large for coupling; we have found clipping the bulb before it excessively dilates effectively controls sizes for anastomosis.¹¹ The inclusion of all veins is the physiologic basis of our lower, caudal incision.

Our decision to commit to the SIEA flap is based on a simple intraoperative algorithm alluded to above. First we palpate the artery to assess flow characteristics. A strong palpable pulse heralds a large enough diameter for inflow. We do not use size as a measure for the artery and have performed <1-mm anastomosis with successful flaps. Second, we assess the SIEV, and require a 1.5-mm vessel for outflow. Veins of this caliber suggest dominance over the deep system and facilitate coupling. Finally, we generally require pedicle length at least twice the thickness of the flap for inset purposes, although this is not a hard and fast rule. Careful examination of both sides is necessary if bilateral SIEAs are to be pursued as caliber may not match. Once committed to the SIEA flap, superior and midline incisions are made and the flap is raised off the anterior rectus sheath. The vessels are freed posteriorly, the artery is clipped flush to the femoral artery for maximum diameter, and the vein (or veins) is clipped at a point for sound venous coupling. To decrease traction/spasm issues, we routinely de-epithelialize the flap *in situ*.

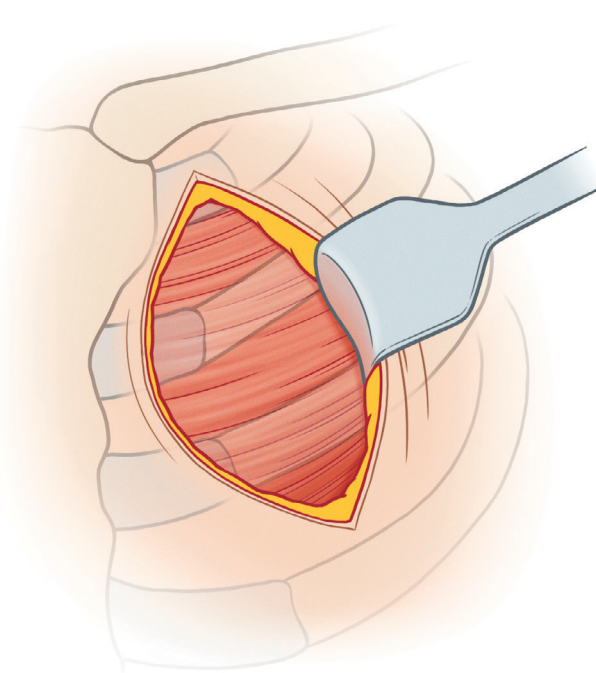
Rib-Sparing Internal Mammary Harvest

Our preferred recipient vessels are the internal mammary artery (IMA) or IMA perforators through a rib-sparing approach. Conventional approaches to the IMA for harvest require removing a costal cartilage from the third or fourth rib. This invasive approach can be associated with intercostal neuralgia and chest wall deformity. A prerequisite to the rib-sparing technique is an interspace that is two fingerbreadths wide, generally at the second or third intercostal space (Fig. 4.7).¹³

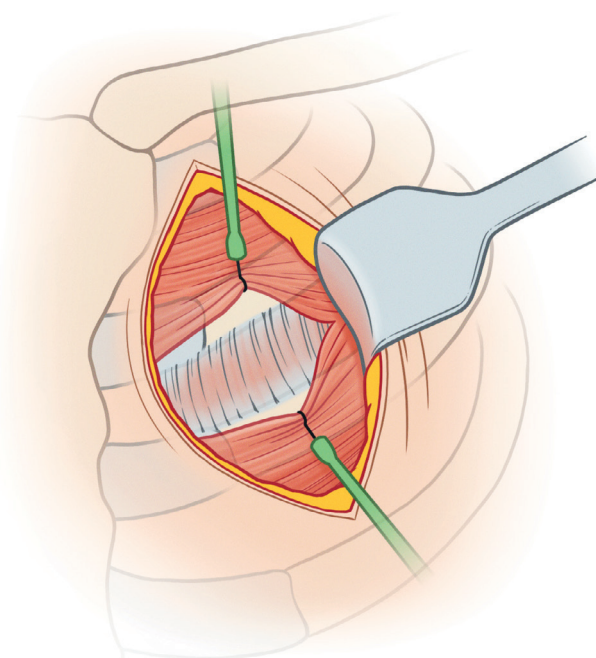
The pectoralis major muscle is split and retracted along its fiber length (Fig. 4.8). Beginning at 3 cm away from the sternal edge, the intercostal muscles are removed layer by layer with bipolar cautery. The deep fascia of the intercostal muscle and loose areolar tissue are removed to expose the internal mammary vessels (Fig. 4.9). Perforators traversing through the intercostal muscles are carefully preserved, as they can often be recipient vessels to the smaller SIE vessels. The perforators are generally largest in ribs 2–4 as seen in the basis for deltopectoral flaps. The internal mammary vessels are 1–2 cm from the sternal border (Fig. 4.10). The vein is medial to the artery in 95% of cases.¹⁴ The resulting intercostal window should provide adequate space to prevent pressure on the anastomosis; costal cartilage trimming can be performed with a rongeur if required.

Microsurgical Technique

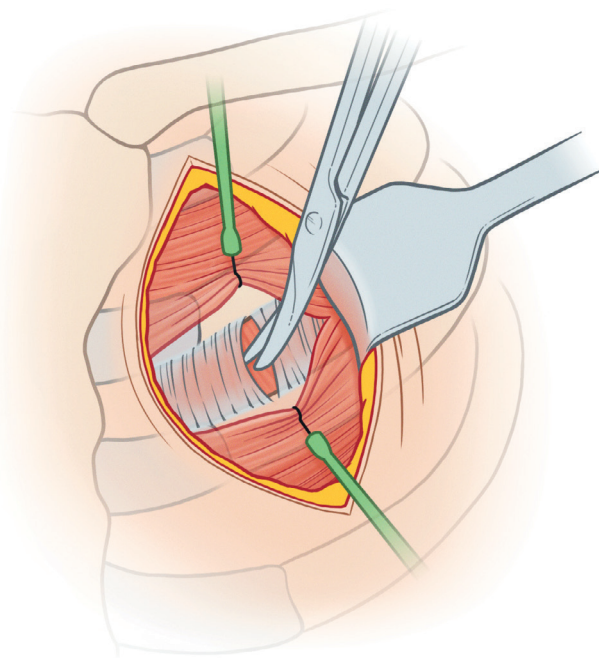
We consider IMA perforators when available, before proceeding to the main vessel in end-to-end fashion. Due to



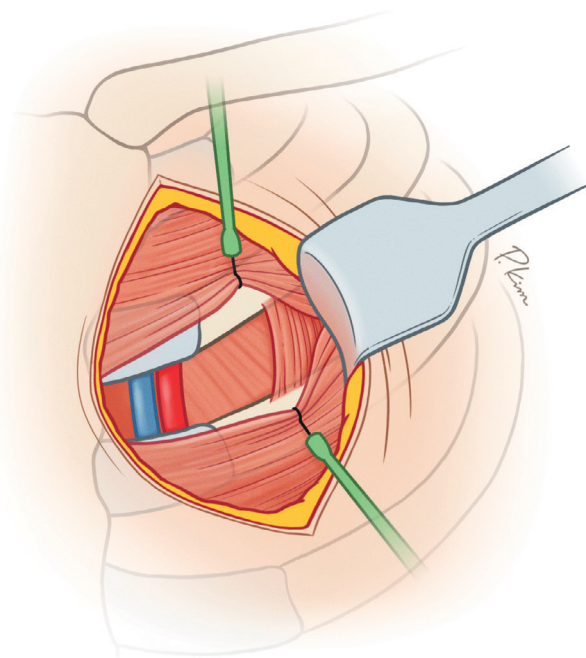
• **Fig. 4.7** The rib-sparing technique requires an interspace of two fingerbreadths wide to allow for adequate space during microsurgical anastomosis. To retract the mastectomy flap, a Richardson within a sterile stockinette is weighted off the field with a 10 pound weight. This provides broadly distributed retraction, resulting in less ischemia.



• **Fig. 4.8** The pectoralis major muscle is split to expose the intercostal segment.

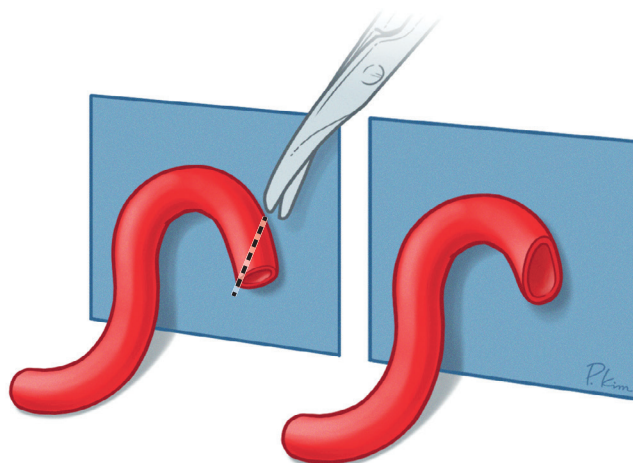


• **Fig. 4.9** The deep fascia of the intercostal muscle is removed to expose the underlying internal mammary vessels. Preserving perforators is important in the SIEA flap, as these perforators may have better size match.



• **Fig. 4.10** The internal mammary vessels are 1–2 cm from the sternal border.

the short pedicle of the SIEA, the anastomosis is often done in a more challenging vertical configuration. The more medial venous anastomosis is performed first with a coupler. Coupling reduces surgical time and makes mismatch easier to manage.



• **Fig. 4.11** Spatulation on the antimesenteric side of the SIEA vessel increases diameter of the vessel for anastomosis and straightens out the vessel once there is flow.

The SIEA vessels have a thick tunica media layer, contributing to its smaller diameter. The SIEAs have a sharp 90–150 degree turn when harvested at the common femorals, as necessary for diameter. We utilize a back cut or spatulation technique to help increase vessel diameter for anastomosis (Fig. 4.11). Alternatively, if a branch point is present, capturing the branch point and opening up the vessel can increase circumference. Demonstrated in our clinical series, spatulation on the antimesenteric (greater curvature) side has been successful at accomplishing two objectives: (1) correcting the size mismatch inherent in an SIEA to IMA vessel anastomosis; (2) straightening the inherent corkscrew-like shape of the vessel when perfusion travels through the vessels. Furthermore, the cuts are performed on the antimesenteric (greater curvature) side of the vessel for ease of vessel anastomosis so one is not sewing with a hanging back wall inside the mesenteric side (as would be undertaken if the cuts to the artery were performed in the opposite manner).

In our most recent study examining 145 SIEA flaps, mismatch was found in 38% of cases. 87% of cases required spatulation, and 7% required slanted back cut on the antimesenteric or greater curvature side.² These techniques were not correlated with flap complications and are encouraged. The only significant difference between the successful and the failed flap groups were the higher proportion of anastomotic revisions intraoperatively (14% vs 50%, respectively). Therefore, rigorous commitment to the vessel set-up and precision is necessary for successful outcome.

The arterial anastomosis is performed with 9-0 sutures in an interrupted fashion. Beginning at the 6 o'clock position, sutures are placed at each point around the vessel to work to visualize the intima at all times. Small bites in the SIEA are taken to avoid functional occlusion of the vessel. In the case of irreconcilable arterial size discrepancy, IMA perforators may be used.¹⁵

Flap Inset

To account for the sharp turns of the SIEA and short pedicle length, use of the contralateral SIEA flap is preferred. De-epithelialization around the necessary skin paddle is performed prior to division and inset instead of after to avoid damaging the microvascular anastomosis. Upon division of the flap pedicle, the flap is rotated 90 degrees so the SIE vessels are pointing medially. Microvascular anastomosis is performed. Upon completion, additional checks are performed to ensure no kinking occurs as a result of the weight of the flap. Two sutures with 2-0 Vicryl (Ethicon, Somerville, NJ) are placed medially to establish an internal brassiere to support the weight of the flap. In immediate reconstructions, the lateral border of the breast envelope may be overdissected. The lateral envelope is tacked down with 2-0 Vicryl

to define the breast borders. Subdermal interrupted and epidermal running sutures are placed to approximate the free and mastectomy flaps after drains are placed.

Abdominal Closure

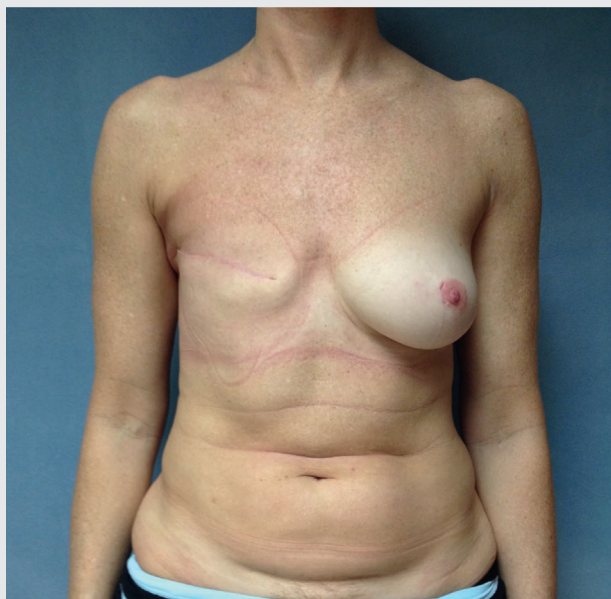
A single 19 French round hubless Blake drain is placed 2–3 cm from the lateralmost aspect of the abdominal closure incision. The drain is longitudinally split to allow drainage of the superior and inferior aspects of the abdominal incision. The entire abdominal incision is tailor-tacked with staples. Scarpa's fascia is closed with 2.0 PDS. 3-0 monocryl is used for subdermal skin closure. A 3-0 running Stratafix (Ethicon, Somerville, NJ) monocryl is used to close the epidermis. The Dermabond Prineo (Ethicon, Somerville, NJ) closure system reinforces the closure.

Case Examples

CASE 4.1

Patient is a 44-year-old non-smoking patient with a history of Pfannenstiel incision desiring abdominal-based flap reconstruction in delayed fashion (Cases 4.1.1 & 4.1.2). She previously had a skin-sparing mastectomy with subsequent radiation. Upon operative exploration, we found that the SIEA and SIEV have been uninjured by the abdominal incisions. After ensuring their patency by intraoperative palpation and close physical examination, we elected to harvest a bi-pedicle SIEA flap for adequate volume to match the contralateral size (Case 4.1.3). The ipsilateral side of the flap was

de-epithelialized (Cases 4.1.4 & 4.1.5). The entire flap was rotated 90 degrees with the lateral aspect contralateral epithelialized portion pointing cephalad and folded in half (Case 4.1.6). The contralateral epithelialized portion plugged into the anterograde, proximal IMA. The de-epithelialized portion was folded so it faces the chest wall and plugged into the retrograde IMA (Cases 4.1.6 & 4.1.7). The patient was very satisfied with the reconstruction at 4-month follow-up (Cases 4.1.8 & 4.1.9).



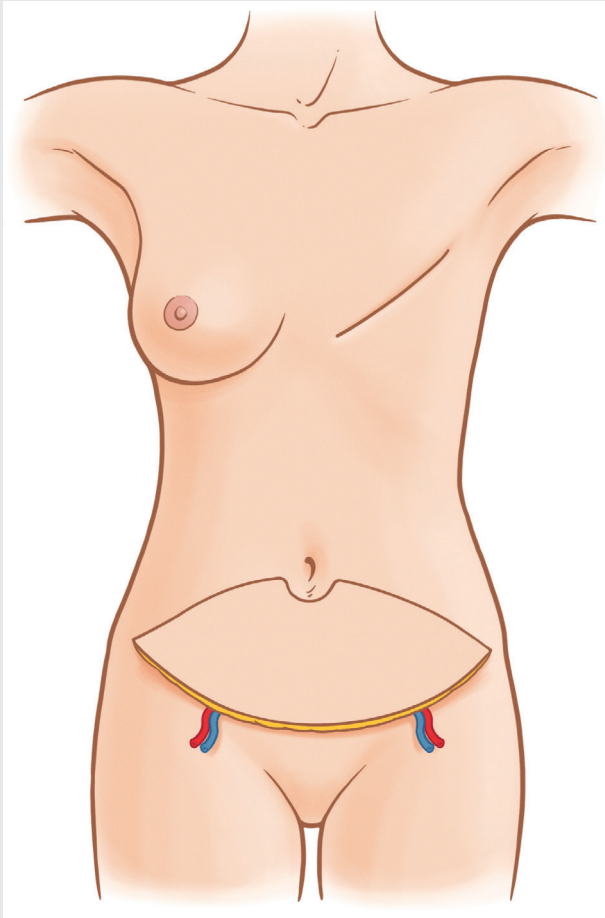
• Case 4.1.1



• Case 4.1.2

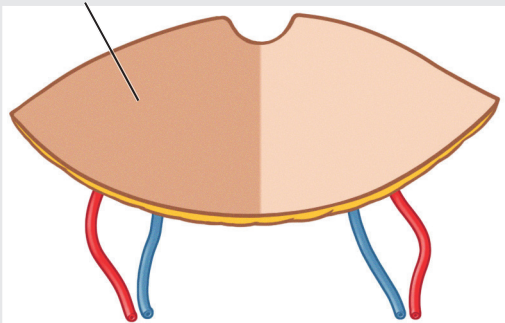
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CASE 4.1—cont'd

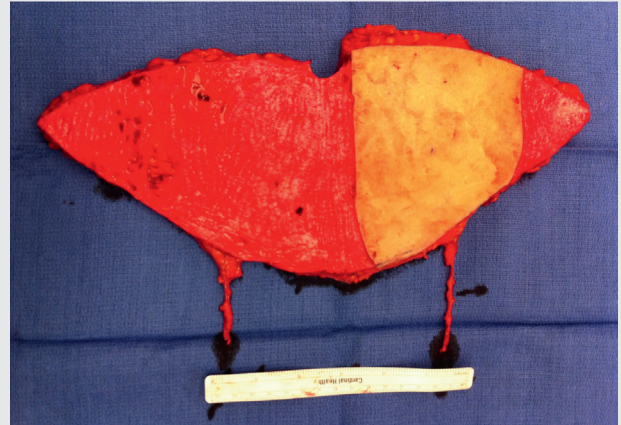


• Case 4.1.3

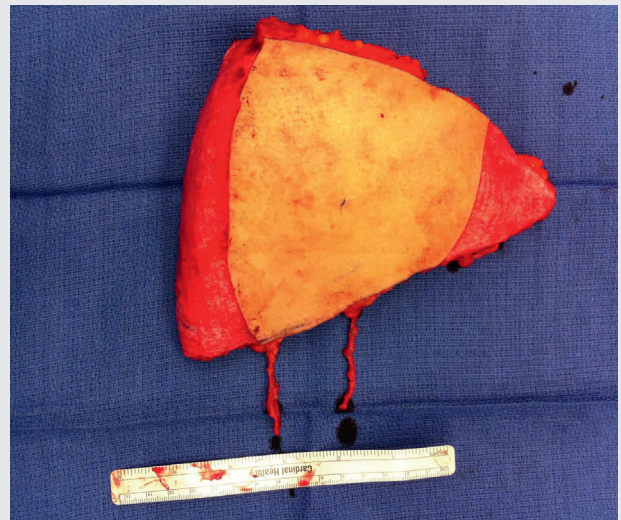
De-epithelialized



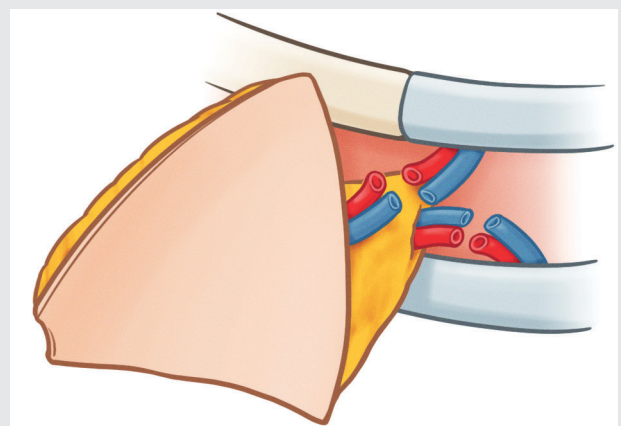
• Case 4.1.4



• Case 4.1.5



• Case 4.1.6



• Case 4.1.7

CASE 4.1—cont'd

• Case 4.1.8



• Case 4.1.9

CASE 4.2

Patient is a 43-year-old non-smoker with a history of left-sided breast cancer and breast conservation therapy (Cases 4.2.1 & 4.2.2). She presented with a new cancer on her right breast and opted for a bilateral mastectomy. Bilateral mastectomies were performed through Wise pattern incisions. On exposure,

her SIEA was palpable and her SIEV was of adequate caliber bilaterally. We performed hemiabdomen bilateral SIEA flaps. Nipple reconstruction with tattooing was performed in subsequent months. On 8-year follow-up, after weight loss, her results were preserved (Cases 4.2.3 & 4.2.4).



• Case 4.2.1



• Case 4.2.2

Continued

CASE 4.2—cont'd



• Case 4.2.3

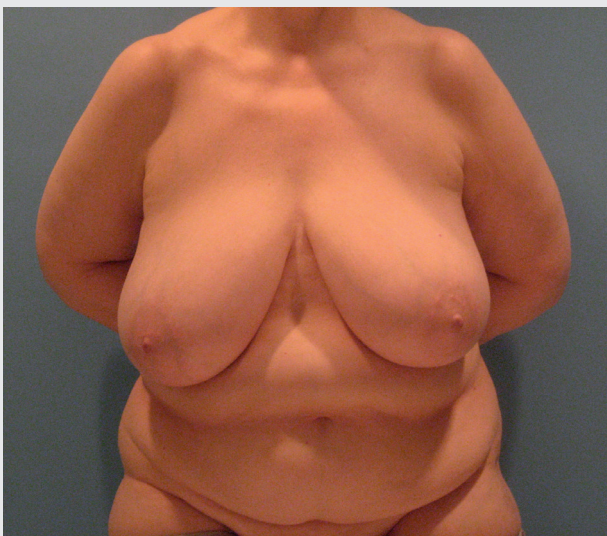


• Case 4.2.4

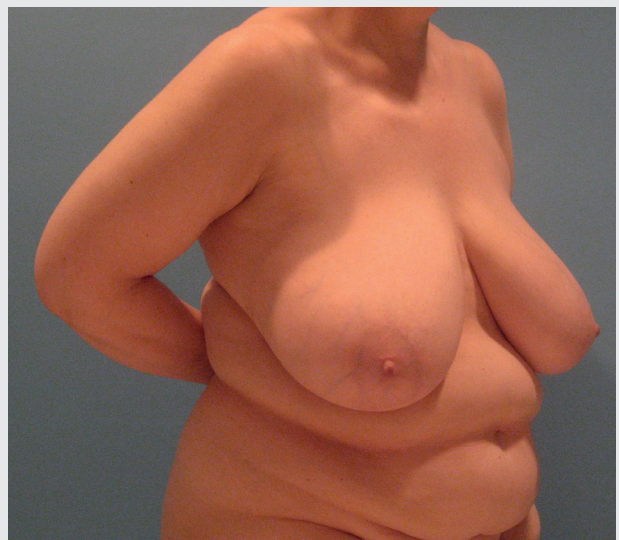
CASE 4.3

Patient is a 65-year-old presenting with left-sided breast cancer (Cases 4.3.1 & 4.3.2). Bilateral mastectomies were performed through Wise pattern incisions. The SIEA was of adequate palpability and the SIEV was of adequate caliber

bilaterally. We performed hemiabdomen bilateral SIEA flaps. Nipple reconstruction with tattooing was performed in subsequent months. On 3-year follow-up, after weight loss, results are preserved (Cases 4.3.3 & 4.3.4).



• Case 4.3.1



• Case 4.3.2

CASE 4.3—cont'd



• Case 4.3.3



• Case 4.3.4

Postoperative Care and Expectations

We now routinely send patients to the floor with use of continuous tissue oximetry (see below) and Q1 hour Doppler checks for 24 hours. Subcutaneous heparin is given for DVT prevention. Use of intraoperative liposomal bupivacaine in the transverse abdominis plane, intraoperative IV acetaminophen, postoperative Toradol, and institution of Enhanced Recovery After Surgery (ERAS) protocol have virtually eliminated narcotic usage in many patients. Bras are placed perioperatively in immediate reconstructions to prevent the movement of flaps in an enlarged breast pocket. However, in the delayed setting, a tight bra may be counterproductive as it adds pressure. Patients are given a diet on day one and are encouraged to ambulate. Patients are generally all discharged home by postoperative day three.

Discharge criteria generally are as follows:

1. Adequate oral intake
2. Ability to void
3. Adequate pain control
4. Ability to ambulate for more than 5 minutes.

We have found that visually highlighting these milestones in the patient room encourages patient participation in their care and reduces hospital stay.

Continuous tissue oximetry has revolutionized our postoperative monitoring protocol. The T.Ox tissue oximeter (ViOptix, Newark, CA) is a non-invasive monitor of real time flap perfusion by measuring scattering and absorption of calibrated wavelengths of near-infrared light, related to the oxygen content of the hemoglobin within the monitored tissue. We currently alert all nurses to call house staff should the perfusion drop by more than 20%.

Management of Complications

The most common complication in a series of 145 SIEA/SCIA breast flaps performed on 119 patients was clinically significant fat necrosis among 15 flaps (10.3%).² Of these cases, five (3.4%) required ultrasound or biopsy, two (1.4%) led to an open wound managed with local wound care, and eight (5.5%) required excision in an additional operation. Fat necrosis trended towards significance in heavier flaps.

Nine flaps (6.2%) in this series required re-exploration for acute thrombosis. Five (3.4%) were due to arterial clots, 3 (2.1%) due to venous clots, and 1 (0.7%) had both arterial and venous clots. None of the flaps with arterial thrombosis were salvaged. Four of the five arterial failures required arterial revisions at the initial operation. Two of the three flaps with venous clots were successfully salvaged. Seven flaps (4.8%) were lost due to anastomotic thrombosis. Overall, failed flaps required significantly more anastomotic revisions on average than successful free flaps (50% vs 14%, respectively).

There were no incidences of hernia or bulge. Dehiscence occurred in 5 flaps (3.4%), seroma/hematoma in 5 (3.4%), and local wound infection in 2 (1.4%). Dehiscence was all managed secondarily with silver sulfadiazine and ABD pads. Seromas may be drained in office with a 20-gauge syringe. Recurrent seromas may require operative debridement of capsule, and placement of drains. Large hematomas similarly require operative re-exploration.

Secondary Procedures

Secondary procedures performed to improve aesthetic appearance of the SIEA flaps are similar to those of other

abdominally based free flaps. Depending on the patient's desires, fat grafting to the upper and lateral aspects of the reconstructed breast is commonly performed. We use the PureGraft (Solana Beach, CA) system for a closed, atraumatic fat preparation technique. The prepared fat is washed and Coleman cannulas with Luer-Lok syringes are used to inject the fat. Large skin paddles left for monitoring may also be secondarily removed by re-elevating the mastectomy skin flaps.

Conclusions

The SIEA flap comprises nearly 30% of our abdominal-based breast reconstruction in our practice. The advantages of this flap are primarily the lack of donor-site morbidity and fascial violation. With advances in microsurgical technique and understanding of anatomy, we have achieved success rates similar to those of the DIEP and MS-TRAM flaps in our practice.

PEARLS FOR SUCCESS

Preoperative

- A low transverse marking for the planned inferior skin paddle ensures adequate inclusion of all venous pedicles.

Intraoperative

- Avoid pedicle traction and arterial spasm by initial anterior dissection only.
- Dissection of the SIEV to the confluence of veins increases diameter and outflow.
- Dissection of the SIEA by opening the cribriform fascia maximizes length.
- Avoid disruption of lymphatics to minimize seroma rates.
- A palpable arterial pulse combined with a >1.5-mm venous diameter is adequate for microsurgical anastomosis and flap survival.
- A length twice the thickness of the flap provides pedicle length for inset.
- Spatulation of the SIEA on the antimesenteric (greater curvature) side increases diameter and lengthens the vessel when flow is present.

Postoperative

- Arterial spasm can be treated to an extent with pain/anxiety control or calcium channel blockers as needed.

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5

Free Gluteal Perforator Flap Breast Reconstruction

JOSHUA L. LEVINE, ALEXANDRA CONDE-GREEN AND PETER ANDRADE

Introduction

The advent of gluteal artery perforator (GAP) flaps has served to increase the surgeon's armamentarium in autologous breast reconstruction. In 1993, Koshima et al. originally described local-regional GAP flaps for repair of sacral pressure sores.¹ Later in 1995, Allen and Tucker described the utility of the free superior gluteal artery perforator (SGAP) flap in breast reconstruction.² Even in thin patients, GAP flaps offer an excellent source of autologous tissue. GAP flaps render soft tissue with a high fat-to-skin ratio, which can be favorable in selected patients. Furthermore, abdominally based flaps may be unavailable due to prior surgery or inadequate volume. Hence, GAP flaps have been championed as an alternative to abdominally based free flaps.

In 2004, Allen et al. further refined the inferior gluteal artery perforator (IGAP) flap to be included into the infra-gluteal crease, resulting in a more cosmetically acceptable surgical footprint.³ As with any other perforator flap, muscle is spared which decreases the donor-site morbidity leading to a faster recovery. Additionally, the muscle functionality is preserved. Typical pedicle lengths are 7–10 cm in an IGAP and 5–8 cm in an SGAP.⁴ Despite the fact that thigh flaps have essentially replaced buttock flaps as the second choice for perforator flap breast reconstruction, reliability of the tissue quality, abundance of volume, and a reasonable pedicle length of GAP flaps make these operations an essential part of a microsurgeon's armamentarium.

In this chapter, the authors describe the indications and contraindications of GAP flaps for breast reconstruction with emphasis on patient selection, operative techniques, postoperative care, and management of complications.

Indications and Contraindications

Gluteal artery perforator flaps can be considered in women who have undergone mastectomies and desire autologous tissue reconstruction. Other indications include hypomastia, Poland syndrome, anterior thoracic hypoplasia,

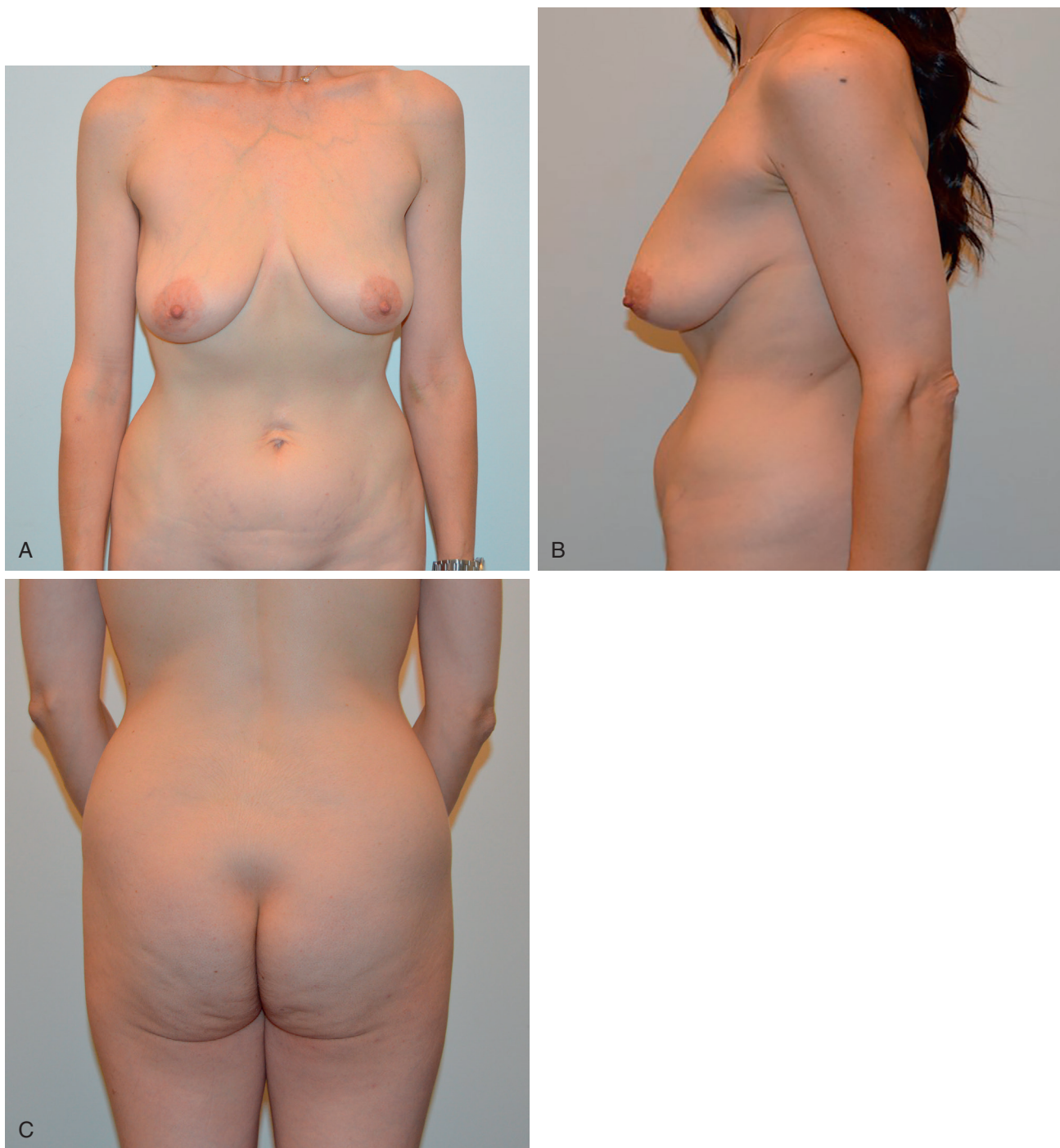
and correction of breast asymmetry.^{5,6} Ultimately, it is the patient's decision as to where she wants the donor-site scar burden to be located. Women who have had surgery that precludes abdominally based reconstruction or have insufficient abdominal tissue are candidates for GAP flap reconstruction. Prior abdominoplasty and extensive liposuction of the abdomen may render the abdomen unusable for perforator flap-based reconstruction. GAP flaps are a logical alternative. Sometimes a patient does not want a long scar that she can see on her lower abdomen, and would prefer a hidden scar in the back (Fig. 5.1).

Liposuction of the buttocks or is a relative contraindication to GAP flap reconstruction. If the area of liposuction was confined to only a portion of the buttock, sometimes a gluteal flap can be designed on a vessel in the non-operated area.

Preoperative Evaluation

As with any surgical procedure, preoperative patient optimization is paramount. It is equally important to manage patient expectations prior to surgery and discuss goals of the surgery, scar burden, possibility of flap complications, and the need for further revisional surgery. A full review in detail of the past surgical history and patient medication list is indispensable as these can potentially preclude surgery.

Magnetic resonance angiograms (MRA) are a mainstay of our patients' preoperative work-up⁷ (Fig. 5.2). The angiograms allow a qualitative evaluation of perforator location, course, and caliber. Hence, they are integral to the presurgical planning. Our radiologists use a coordinate system with reference points such as the midline and the gluteal fold to describe the perforators' location as they exit the muscle. Each perforator coordinate is measured in its vertical and horizontal position with respect to these landmarks. Perforator selection is multifactorial, which is why each case must be tailored according to the imaging and patient body habitus. A large vessel diameter, pedicle of sufficient length



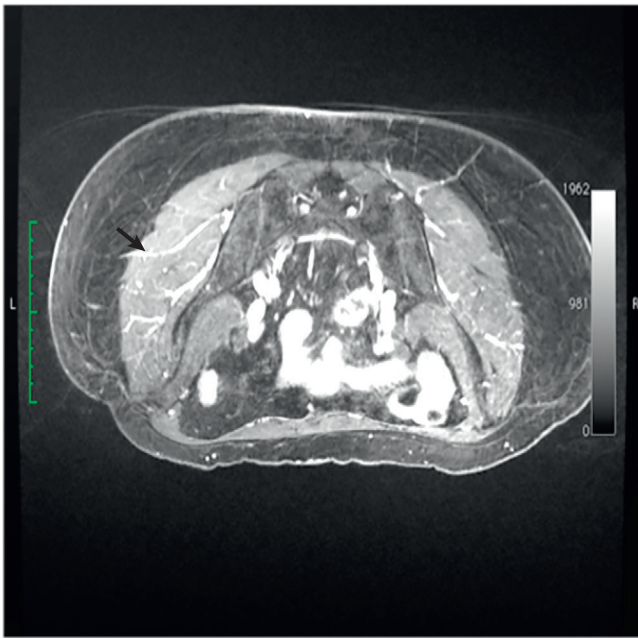
• **Fig. 5.1** The ideal patient for bilateral superior gluteal artery perforator flaps. (A–C) A 40-year-old female, BMI 28, who is scheduled for bilateral prophylactic mastectomy, *BRCA1* positive, presenting minimal abdominal donor site and acceptable gluteal tissue that can be used for donor site.

for inseting, central location of the vessel on the flap, or a pattern of arborization that suggests perfusion of the tissue to be transferred are all considered favorable for the choice of the pedicle to be used. Use of the angiogram in conjunction with a pencil Doppler facilitates the most accurate identification of the perforators prior to the surgery. This method is particularly helpful in designing the skin paddle that will capture the perforators.

Surgical Techniques

Relevant Anatomy of the Gluteal Region

The gluteus maximus muscle measures approximately 24×24 cm. It originates from the posterior superior iliac spine, the coccyx, and the lateral aspect of the sacrum. The muscle inserts into the greater trochanter and the iliotibial tract of the fascia lata.

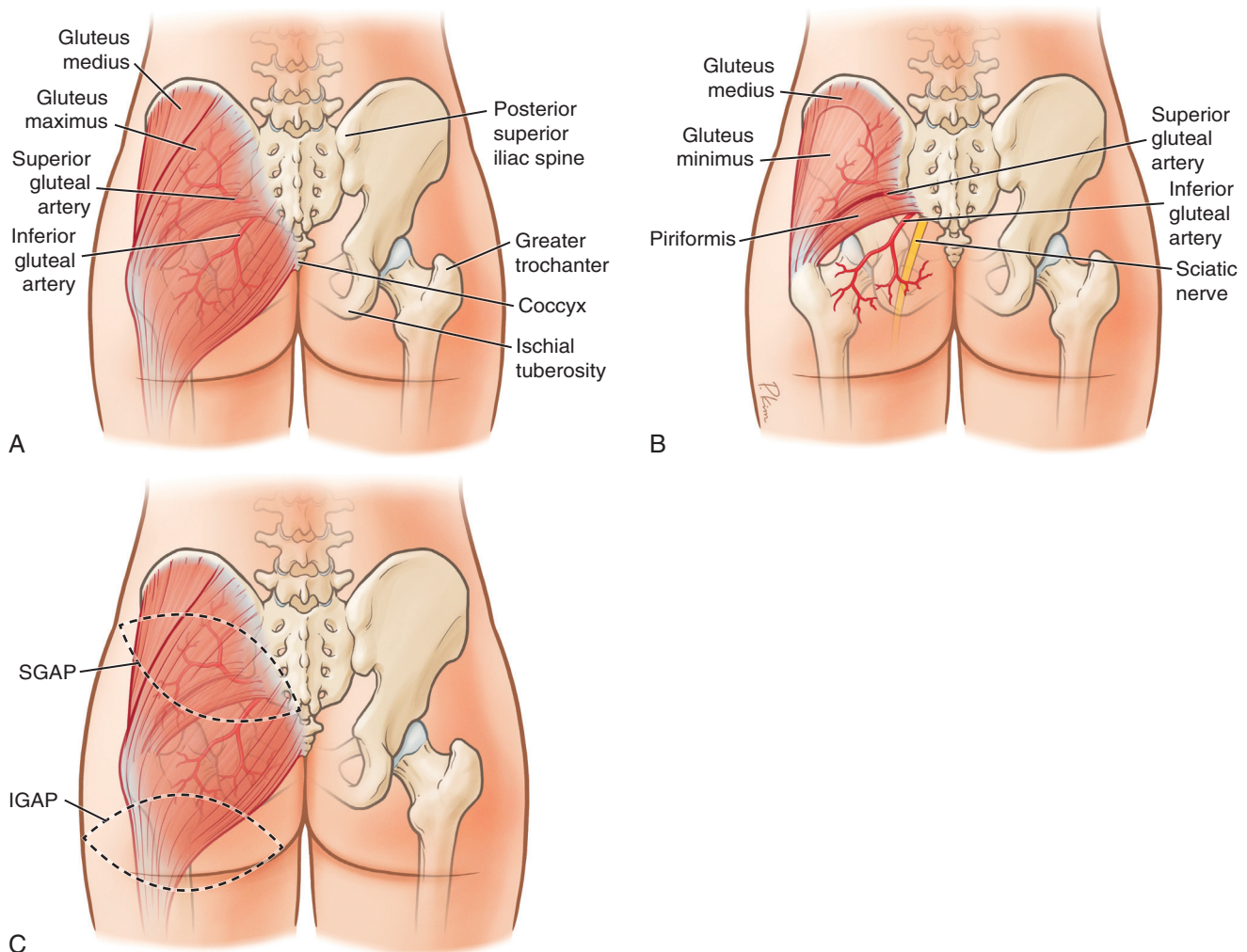


• **Fig. 5.2** Magnetic resonance angiogram of gluteal artery perforators.

The superior gluteal artery arises from the internal iliac artery and exits through the greater sciatic foramen, above the piriformis muscle perforating the gluteus maximus muscle to supply the overlying skin and fat. The exit point corresponds anatomically to 6 cm below the posterior superior iliac spine and 4.5 cm lateral to the midline of the sacrum. The inferior gluteal artery also arises from the internal iliac artery and along with the sciatic nerve and emerges below the piriformis muscle (Fig. 5.3).

Preoperative Marking

Typical skin paddles range from 6–10 cm in width by 18–22 cm in length. It is incumbent on the surgeon to resect a skin island that will facilitate a tension-free closure. A patient's preference towards a superior or inferior flap is influenced by the advantages and disadvantages of each gluteal flap procedure. Anatomic considerations are based on a patient's distribution of fat on the buttock and location of the most favorable vessels in the buttock.



• **Fig. 5.3** Surgical anatomy of the gluteal region. (A) Bony landmarks for the gluteus muscle. (B) Neuro-vascular anatomy under the gluteus maximus muscle. (C) Flap design for SGAP and IGAP flaps.

In an SGAP flap, the skin island is elliptical with an oblique axis slanting cephalad from medial to lateral. To limit conformational change, the MRA and the marking should be done in the prone position. The scar of the SGAP can be covered with a bathing suit, however it is located in a more prominent position on the buttock, therefore, harvesting a superior gluteal flap can disturb the superior fullness of the buttock, causing unfavorable flattening of this area (Fig. 5.4).

In an IGAP flap, the skin island is elliptical, and the inferior border of the flap should be parallel and placed about 1 cm inferior to the gluteal fold. The fold should be identified with the patient in a standing position. The flap design could be shifted laterally to address “saddlebag” deformities if needed. The scar from an inferior gluteal flap is located in a less prominent area of the buttock in the inferior gluteal crease and can be hidden. The scar is typically visible lateral to the buttock crease, and the natural curve of the inferior buttock crease can be unfavorably flattened (Fig. 5.5).



• Fig. 5.4 Marking of bilateral superior gluteal artery perforator flaps.



• Fig. 5.5 Marking of unilateral superior gluteal artery perforator flaps.

Preoperative Setting and Patient Positioning

For deep venous thrombosis prophylaxis, a subcutaneous heparin injection is given preoperatively and sequential compressive devices are placed on the legs. A prophylactic dose of antibiotic is given, a urinary catheter inserted and general anesthesia given. For a unilateral breast reconstruction, the patient is placed in the lateral decubitus position with appropriate padding of pressure points supported with a bean bag. The upper and lower extremities on the side of the breast reconstruction are prepped in the field. For a unilateral breast reconstruction, a gluteal flap is harvested from the same side of the body as the reconstructed breast. The mastectomy and GAP flap dissection can be performed simultaneously (Fig. 5.6). After the flap is harvested, the patient is placed in supine position for microsurgical anastomosis to the internal mammary vessels and flap inset. For bilateral simultaneous breast reconstruction, the patient is first placed in a supine position for the mastectomy and preparation of the recipient vessels in the chest. The patient is then placed in the prone position for harvesting of the GAP flaps and closure of the donor sites. The patient is turned again to the supine position for microsurgical anastomosis and flap inset.



• Fig. 5.6 Positioning of the patient for unilateral left inferior gluteal artery perforator flap harvest.

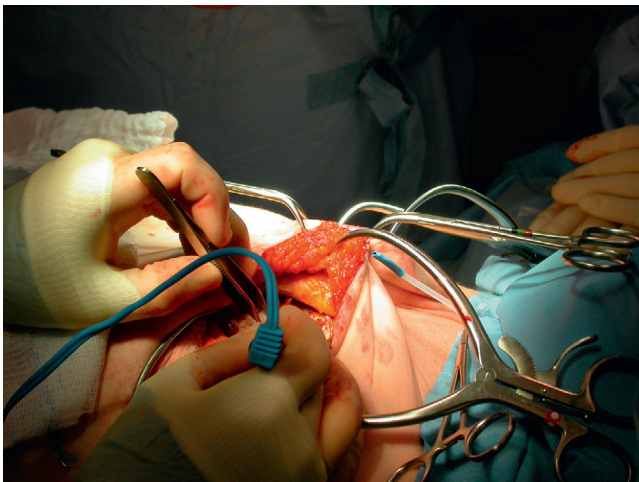
Operative Procedure

A team of two microsurgeons operate simultaneously. The preparation of recipient vessels in the chest and the dissection of the gluteal vessels are performed with loupe magnification.

Recipient Site Exposure

The most commonly used recipient vessels are the internal mammary vessels, which run parallel to the sternum, under the ribs (Fig. 5.7). The muscle fibers of the pectoralis muscle are separated at the intercostal space between the second and third or third and fourth ribs. The perichondrium is elevated off the most medial portion of the ribs and the most medial section of the intercostal muscle is resected. A pale yellow layer of fat containing the internal mammary vessels is located under the intercostal muscle and over the pleura. The internal mammary artery is accompanied by one or two veins. The vessels are carefully dissected from the surrounding fat using a bipolar cautery. Side branches of the vein are preserved distally to create a wider lumen in case of size mismatch with the gluteal vein. An intercostal space of 2–3 cm is sufficient to perform the anastomosis. If more space is required, a portion of medial rib cartilage can be removed. The arterial size match is usually favorable if the GAP pedicle dissection was pursued all the way to the source vessel (SGA or IGA). If the pedicle was harvested prior to the larger artery, the pedicle vessel may be of smaller diameter. In this case, a better arterial size match may be achieved by using a perforating artery or a branch off of the internal mammary artery.

In delayed reconstruction, the recipient site is prepared by creating a pocket where the breast parenchyma was once located, under the subcutaneous tissue overlying the pectoralis muscle, for the gluteal flap to rest in.



• **Fig. 5.7** Set-up for bilateral simultaneous dissection of internal mammary recipient vessels.

Flap Dissection

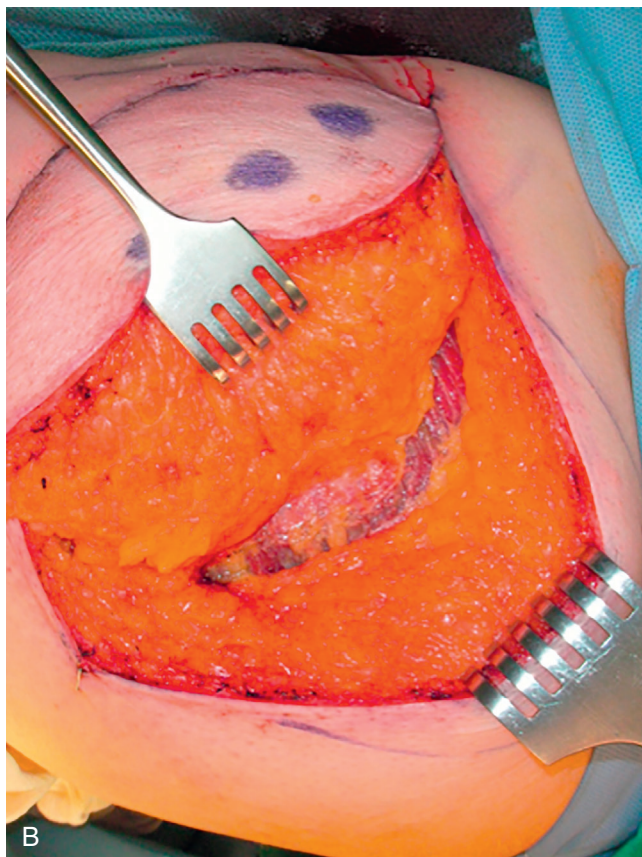
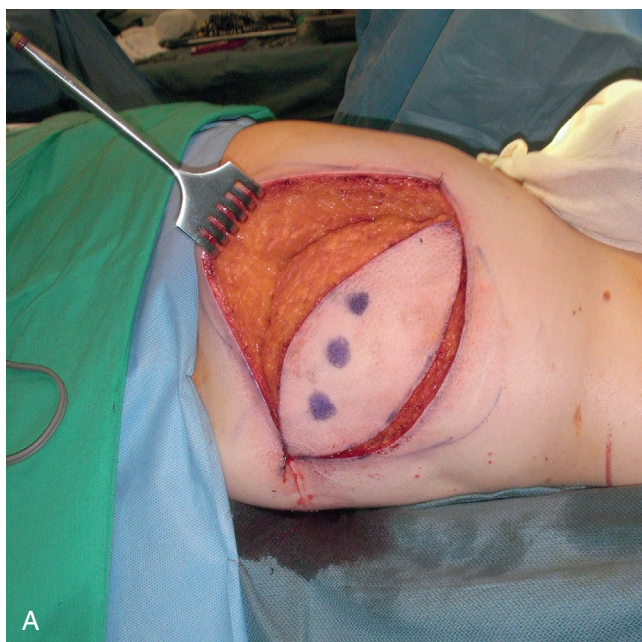
An incision is made along the planned skin pattern of the GAP flap whether it is an SGAP or an IGAP. Subcutaneous fat is beveled to yield adequate volume and to obtain a more rounded flap suitable for breast reconstruction (Fig. 5.8). Once the gluteal fascia is incised, the flap is elevated under loupe magnification from either apex of the flap perpendicular to the direction of the muscle fibers using a bipolar cautery. Each muscle bundle is uncovered to the extent of the entire field prior to moving to the next bundle, resulting in a neat dissection, so that the perforators are easily visible when they emerge within the septum between two muscle bundles. Once the key perforator is identified and selected, the natural septum between the muscle bundles through which it emerges is separated (Fig. 5.9). This separation is developed to the extent of the entire wound to ensure a wide field of dissection as the perforator is traced down to the gluteal vessels.

As dissection proceeds proximally towards the main superior or inferior gluteal artery trunk, multiple side branches are ligated and the vessel caliber increases (Fig. 5.10). The pedicle is transected when an adequately sized artery is reached (Figs. 5.11–5.13). Underneath the gluteus maximus muscle a plexus of large, thin-walled venous branches emerges, referred to as “Medusa’s head”. In the SGAP dissection, a thick layer of deep fascia is encountered, and must be opened widely (Fig. 5.14). This allows for adequate exposure of the venous branches which must be dissected in order to gain access to the artery. Perseverance in this area is rewarded with an artery of adequate diameter to reasonably match with the internal mammary artery. The vein at this level can be as large as 3–4.5 mm, even up to 6 mm.

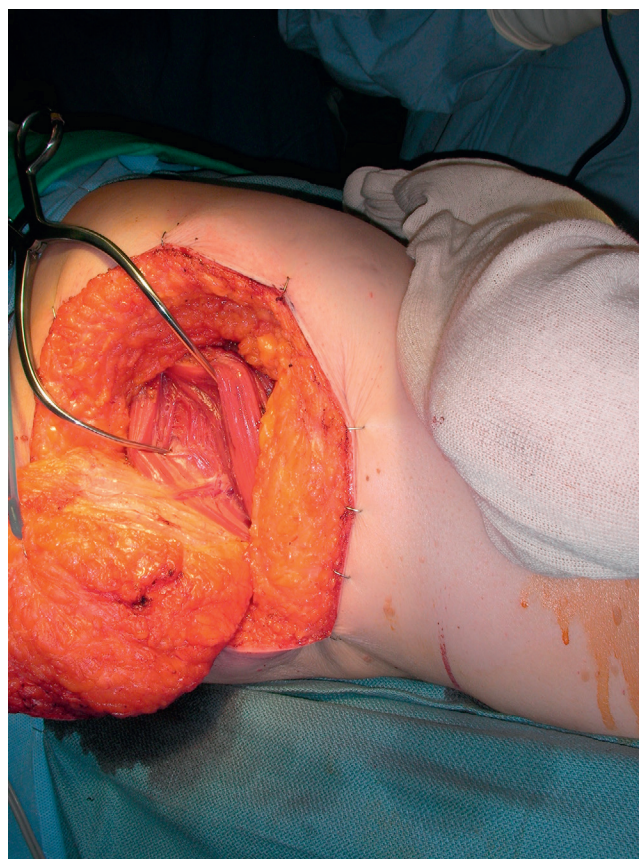
After the flap is harvested (Fig. 5.15), the donor site is closed over a drain in two layers with interrupted absorbable sutures and the skin is sutured with interrupted absorbable sutures. In order to reduce the risk of a seroma at the donor site, closure of the buttock must be done with care to obliterate dead space.

Anastomosis

The gluteal flap is brought to the chest and care is taken to align the pedicle with the recipient vessels without any torsion, kinking and tension. In bilateral gluteal flap procedures, the decision of which flap to use at each recipient site (e.g. right gluteal flap to right chest or right gluteal flap to left chest) is determined by placing the gluteal flap into the recipient site pocket and observing the location of the pedicle entering the flap when the flap is optimally inset. The medial location of the recipient vessels allows the flap to be inset medially where the breast volume is most needed. The gluteal flap is temporarily sutured to the skin of the chest to prevent it from shifting and causing any stretch or avulsion of the anastomosis. The microscope is used for the anastomosis of the gluteal flap vessels to the recipient chest vessels. The veins are anastomosed first using a coupling



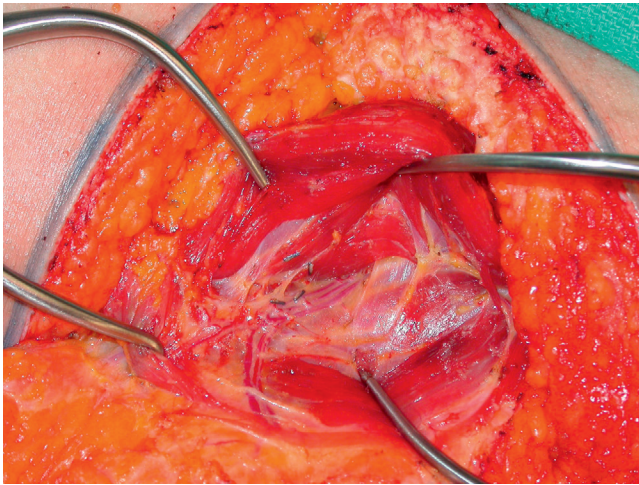
• **Fig. 5.8** (A) Unilateral left gluteal artery perforator dissection with patient in the lateral decubitus position. (B) Beveling is used to maximize harvest.



• **Fig. 5.9** Left superior gluteal artery perforator dissection with the patient in the lateral decubitus position.



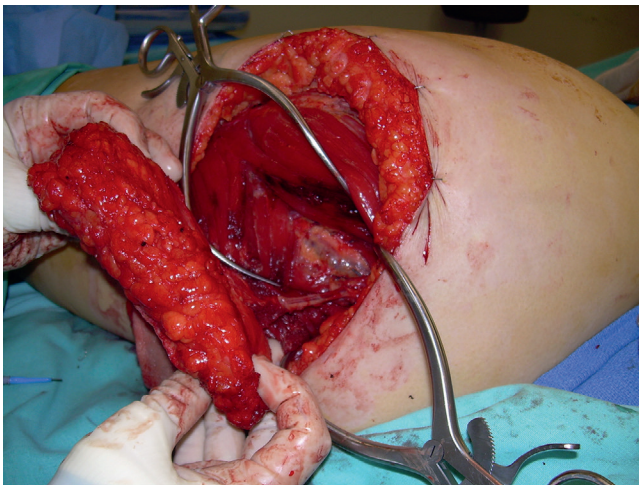
• **Fig. 5.10** The gluteal artery perforator is identified emerging between muscle bundles.



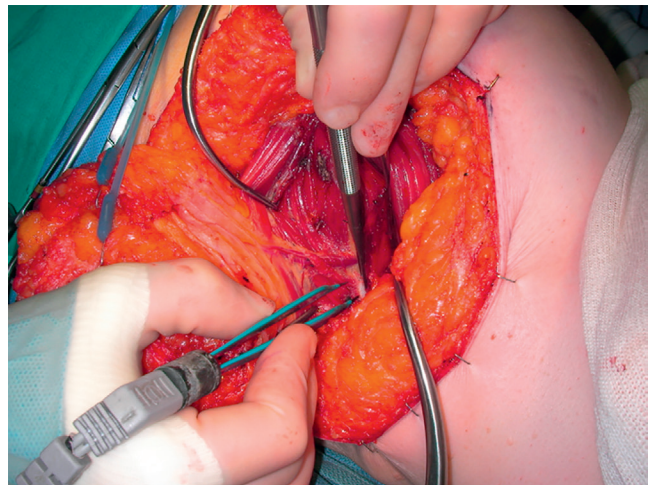
• **Fig. 5.11** Superior gluteal artery perforator pedicle dissected.



• **Fig. 5.13** Inferior gluteal artery pedicle length (flap weight: 520 g).



• **Fig. 5.12** Superior gluteal artery perforator (435 g) and pedicle dissected and ready for harvest.



• **Fig. 5.14** Cutting the deep gluteal fascia to get to "Medusa's head" in SGAP dissection.

device. A coupling device stents the veins open and is faster than sutures. The arteries are joined together with a hand-sewn anastomosis with Nylon 9-0 (Fig. 5.16). The patency of the vein is checked by observing filling of the recipient vein proximal to the anastomosis. An arterial pulse and a manual Doppler signal is checked in the distal pedicle. Manual external Doppler signals of the gluteal artery perforator and vein are confirmed on the skin and a suture mark is placed. The color and capillary refill of the skin flap is checked. In some cases, the SGAP pedicle is short, measuring less than 6 cm, then more length may be obtained on the internal mammary vessels by taking out a rib cartilage.

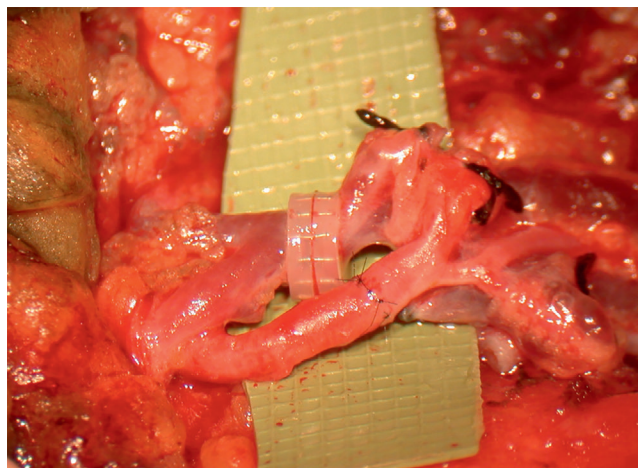
Flap Inset

The gluteal flap has a higher fat to skin ratio, the fat may be more spongy and firm making it less pliable in shaping for breast reconstruction. The amount of skin available may be less than with an abdominal flap in some patients, however with proper planning and realistic expectations, these issues can be overcome.

Excess flap skin is de-epithelialized and the flap is inset over a drain using absorbable sutures. An island of gluteal flap skin is left visible for flap monitoring and can be used for future nipple reconstruction. A supportive surgical bra is applied.



• **Fig. 5.15** Left IGAP donor site after harvest.



• **Fig. 5.16** Anastomosis of the gluteal flap vessels with to the recipient chest vessels. Coupling of the veins and hand-sewn arterial anastomosis.

Case Examples

CASE 5.1

This 41-year-old patient is status post unilateral mastectomy with a history of implant failure and inadequate abdominal donor site volume. She has satisfactory inferior gluteal tissue.

Case 5.1.1 shows preoperative (A) and one-week postoperative (B) views of the left inferior gluteal artery perforator flap donor site.



A



B

• **Case 5.1.1**

CASE 5.2

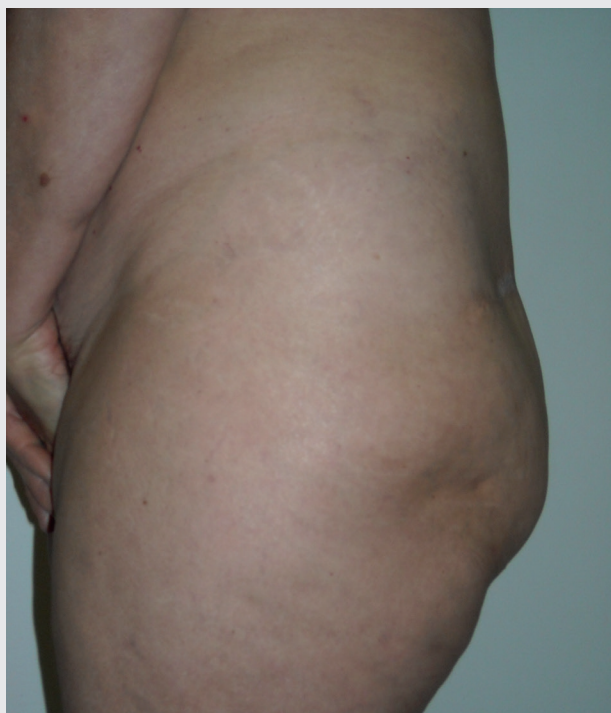
This 47-year-old patient is status post bilateral mastectomy with a history of multiple abdominal operations with ample upper gluteal tissue (Case 5.2.1). Postoperative view of bilateral superior gluteal artery perforator flap donor site is shown in Case 5.2.2. Postoperative frontal and oblique views of breast reconstruction with bilateral SGAP are shown in Cases 5.2.3 and 5.2.4.

Case 5.2.5 shows preoperative (A) and postoperative (B) views of a 42-year-old patient, BRCA1 positive, who had prophylactic bilateral skin-sparing mastectomies, no radiation, no chemotherapy, and who benefitted from bilateral inferior gluteal artery perforator flaps. There were no complications. Preoperative (A) and postoperative (B) views of bilateral inferior gluteal artery perforator donor site are shown in Case 5.2.6.



• Case 5.2.1

CASE 5.2—cont'd



• Case 5.2.2

CASE 5.2—cont'd



• Case 5.2.3



• Case 5.2.4

Continued

CASE 5.2—cont'd



• Case 5.2.5

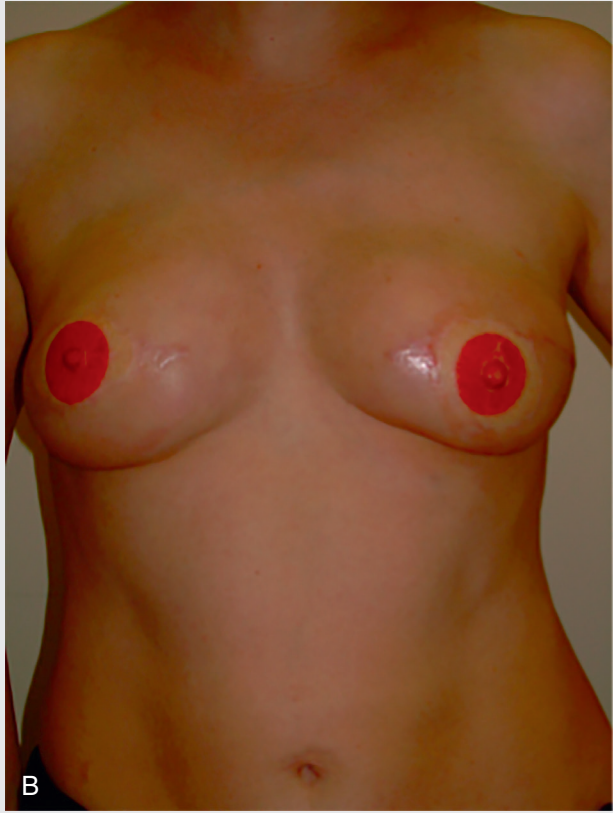


• Case 5.2.6

CASE 5.3

This is a 39-year-old female, BMI 23.5, with a history of bilateral mastectomy, no radiation, no chemotherapy, who initially had breast reconstruction with tissue expanders (Case 5.3.1A) but due to the discomfort, she opted for autologous

breast reconstruction. We proposed bilateral SGAPs to her as she did not have sufficient abdominal donor tissue. The postoperative photo is a 3-year follow-up (Case 5.3.1B).



• Case 5.3.1

Postoperative Care and Expected Outcomes

An occlusive dressing is applied on the incisions and compressive garments are used to control edema and limit dead space on the gluteal donor sites. After surgery and recovery, the patient is transferred to a floor bed with trained micro nursing staff. Flap checks are performed every 15 minutes for the first hour, and every 30 minutes for the second hour. The flap check interval is lengthened periodically until discharge. Flap exams consist of assessing arterial and venous signals with a handheld Doppler via the skin paddle, as well as assessing flap color, turgor, capillary refill time, and signs of congestion or swelling. The patient remains NPO and at bed rest until postoperative day one. On the morning after the procedure, a regular diet is given for breakfast, the Foley is removed, and the patient is out of bed ambulating. Typically, the patients are allowed to take a shower on the third

postoperative day and are discharged with oral antibiotics and analgesics. Drains are left in place until outputs are less than 30 cc per day. Compressive garments remain on the donor site for 2 weeks to reduce seroma and edema.

Patients are advised that there should be no heavy lifting or rigorous activity for 1 month after the procedure. Most patients are then able to return to work. During the recovery period, pain is controlled mostly with non-steroidal anti-inflammatories and acetaminophen.

Management of Complications

Overall complications of GAP flaps are low. In the case of questionable vascular compromise, clinical exam of the flap is ultimately what determines the need for return to the operating room. Under the microscope, the venous and arterial anastomosis are scrutinized and revised when indicated. A systemic bolus of heparin is typically given during

anastomotic revision if there are no other signs of bleeding. Flap take back and flap loss is less than 5% and 1%, respectively. A common complication is contour deformity of the donor site. Fat grafting is typically performed for correction of this deformity. If seroma formation occurs, percutaneous aspiration or ultrasound-guided drainage is performed. Fat necrosis, dog-ears at the donor site, contour irregularities of the gluteal region, wound dehiscence, wound infection and breast asymmetry are also potential complications. Any lingering issues are addressed in a second revision surgery, performing fat grafting to enhance volume and correct areas of asymmetry, or local flap mobilization. Rarely, temporary paresthesias can occur if the posterior femoral cutaneous nerve is stretched during harvest of an inferior gluteal flap.

Secondary Procedures

The second stage of the procedure can be performed in an ambulatory setting two to three months after the initial procedure. Most patients require a second stage revision of the reconstructed breasts or the donor-site incisions or both. Adjustments are made to the reconstructed breast to improve symmetry. A nipple reconstruction may be needed from the flap skin paddle. An increasing number of patients in our practice benefit from nipple-sparing mastectomy, therefore the gluteal flap skin that was left visible for monitoring is removed as early as the first week postoperative depending on the viability of the nipple. Adjustments to the donor site can also be performed, such as excision of a “dog-ear” or liposuction to smooth the contour. The nipple and areola are tattooed about 6 weeks after the nipple reconstruction and can require two to three sessions as the tattoo pigments fade with time.

Conclusions

The GAP flaps are an excellent option for patients in whom the abdomen is not an ideal donor site. With the development of the thigh perforator flaps (profunda artery perforator and lateral thigh perforator), we have found that most women who are candidates for GAP flaps are also candidates for thigh flaps. Thigh flaps can be done with the patient in the supine position, and the pedicle length is in general much longer. The donor defect also tends to be less problematic cosmetically. For these reasons, the thigh flaps have largely replaced the GAP flaps in most patients. However, there will always be patients who are

ideal candidates for GAP flaps, prefer the GAP scar, or are not candidates for the use of other donor sites due to prior surgery. For these reasons, the GAP flap will always be an important part of the reconstructive breast surgeon's armamentarium.

PEARLS FOR SUCCESS

- Preoperative MRA is extremely useful in planning the procedure.
- Remove gluteal fascia from one muscle bundle at a time to the extent of the surgical field.
- Follow the pedicle past the deep gluteal fascia (which must be incised) and beyond the “Medusa's head” to obtain adequate length and diameter of the pedicle and artery.
- In the deepest part of the dissection, it is vitally important to proceed with caution so as not to traumatize one of the large deep gluteal veins.
- If uncontrollable bleeding is encountered during the deep dissection, it may be necessary to amputate the pedicle in order to maintain hemostasis.
- Continue the dissection until the diameter of the artery is at least 1.5 mm and the pedicle length is greater than 7 cm.
- Separate the artery from the vein before harvesting the pedicle.
- Remove a rib cartilage if the pedicle length is too short for unsetting with no tension.

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6

Free Profunda Artery Perforator Flap Breast Reconstruction

JUAN JOSE GILBERT FERNANDEZ, JENNIFER LAVIE, TORUNN E. SIVESIND, HUGO ST. HILAIRE AND ROBERT J. ALLEN SR

Introduction

Breast reconstruction is a common challenge faced by many surgeons working in the plastic and reconstructive arenas. There are various options for autologous breast reconstruction. The more commonly performed procedures include the deep inferior epigastric perforator flap (DIEP) and the superior and inferior gluteal artery perforator flaps (SGAP, IGAP). Despite the refinements in the latter donor sites, specific reconstructive needs and body habitus sometimes call for an alternate donor site. This has led to the development of the medial thigh as a donor site, more specifically based on the profunda artery system.

The senior author first introduced the PAP flap for breast reconstruction at the 13th International Course on Perforator Flaps in 2010. The patient was a 52-year-old woman with previous failed attempts at breast reconstruction using implants and then a transverse rectus abdominis muscle flap. As the patient had been noted to have excess posterior thigh tissue, Dr. Allen decided to proceed with the first posterior thigh profunda artery perforator (PAP) flap for microsurgical breast reconstruction. This idea was supported by the background work of other surgeons and anatomists, who had previously described the profunda artery anatomy as responsible for the regional blood supply of the posterior upper thigh. The PAP flap had become an innovative addition to the breast reconstructive armamentarium.

The PAP flap has proven to have consistent anatomy and blood supply, with adequate perforator size for anastomosis to the internal mammary or thoracodorsal vessels. Additionally, due to its elliptical pattern used for flap design, it has proven to have excellent aesthetic results, either coned to accommodate the natural contour of the breast, or stacked to create a full-shaped breast.

The donor-site incision is concealed in the gluteal crease in the transverse pattern, or in the transition between the medial and posterior thigh in the vertical pattern. Like all

of the various options for microsurgical free tissue transfer, the PAP flap is not without its disadvantages; however, the reported complication rate has overall been quite low and acceptable as compared to the alternative options for autologous tissue breast reconstruction.

In this chapter, we will focus on providing guidelines for using the PAP flap by discussing the indications and contraindications for choosing this flap for breast reconstruction, how to properly evaluate a patient who appears to be a good candidate for this procedure, our surgical technique, and the postoperative care. Additionally, we will provide some case examples of the various uses of the PAP flap, and some variations to this technique. These include the use of a transverse incision, vertical incision, and its use as stacked flap, “four flap” autologous breast reconstruction with use of DIEP flaps along with PAP flaps. Finally, we will discuss some possible complications, how to avoid them, and appropriate short- and long-term management of patients having this surgical procedure, including the need for secondary procedures for improved aesthetic outcomes.

Indications and Contraindications

Although the DIEP flap has been the workhorse for microsurgical breast reconstruction, there are some circumstances that make the PAP flap a more valuable option. Some indications that favor the use of the PAP flap include patients with previous abdominal surgery and/or thin patients with a paucity of abdominal tissue.¹ There is also a subset of patients who do not wish to use their abdominal tissue for reconstruction, or are trying to avoid an anterior abdominal scar, thus making the PAP flap an ideal option, especially with its inconspicuous donor site scar.¹ The PAP flap has been harvested on patients with various body mass indexes; the ideal patient has small to moderate-sized breasts and excess body fat below the waist.¹ The PAP flap has also been used in different reconstructive scenarios such as lower

extremity and head and neck reconstruction.² The PAP flap has no major contraindications; however, we see a limitation in those patients who have limited hip abduction or previous surgery to the inferior gluteal crease region.

Preoperative Evaluation and Special Considerations

The PAP flap has proven to have consistent anatomy; however, preoperative imaging is paramount in surgical planning. Current imaging modalities such as computed tomography angiography (CTA) and magnetic resonance angiography (MRA) have demonstrated great utility in the identification of perforator vessels needed for flap harvesting.^{3–5} Saad et al. demonstrated the consistent anatomy for the PAP based on cadaveric dissection and CT scanning, which showed the perforator supplying the medial and posterior thigh skin and subcutaneous tissue just below the buttocks crease. Identification of these perforators has become the standard of care for the surgical planning of the PAP flap (Fig. 6.1).

The CTA technique should be performed in a high-resolution scanner with thin cuts. With the patient in prone position, a marker should be placed in the gluteal crease, which will help provide accurate measurements relating to the perforator position for flap design. The perforators will be identified posterior to the gracilis muscle as septocutaneous or musculocutaneous perforators through the adductor magnus.

Surgical Techniques

Relevant Surgical Anatomy

The PAP flap has very consistent anatomy. The profunda femoris artery branches off the lateral aspect of the femoral

artery 3.5 cm below the inguinal ligament and enters the posterior compartment of the thigh to split into medial and lateral branches before giving off its major perforators: the first perforator supplies the adductor magnus muscle, and the second and third perforators supply the semimembranosus, biceps femoris, and vastus lateralis muscles.

The numerous consistent perforators, in combination with preoperative imaging, have allowed versatility in the design of the skin flap pattern. As such, despite the common use of the transverse design, other orientations such as the vertical and diagonal designs have also been successfully used.

Preoperative Markings

Transverse Flap Design

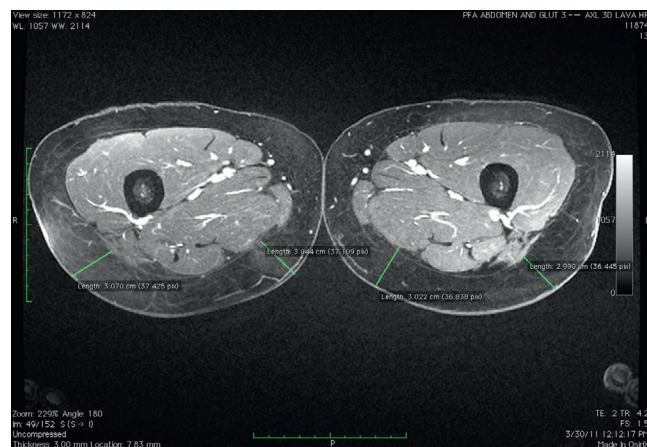
Imaging is key in order to appropriately design the flap. The skin perforators are marked accordingly with a handheld Doppler. The superior margin of the flap is typically marked 1 cm below the gluteal fold, and the inferior margin is marked about 7–8 cm below, to make up for the width of the flap. An elliptical flap is designed, usually measuring about 27 cm transversely with an anterior extension to the adductor longus (Fig. 6.2).

Vertical Flap Design

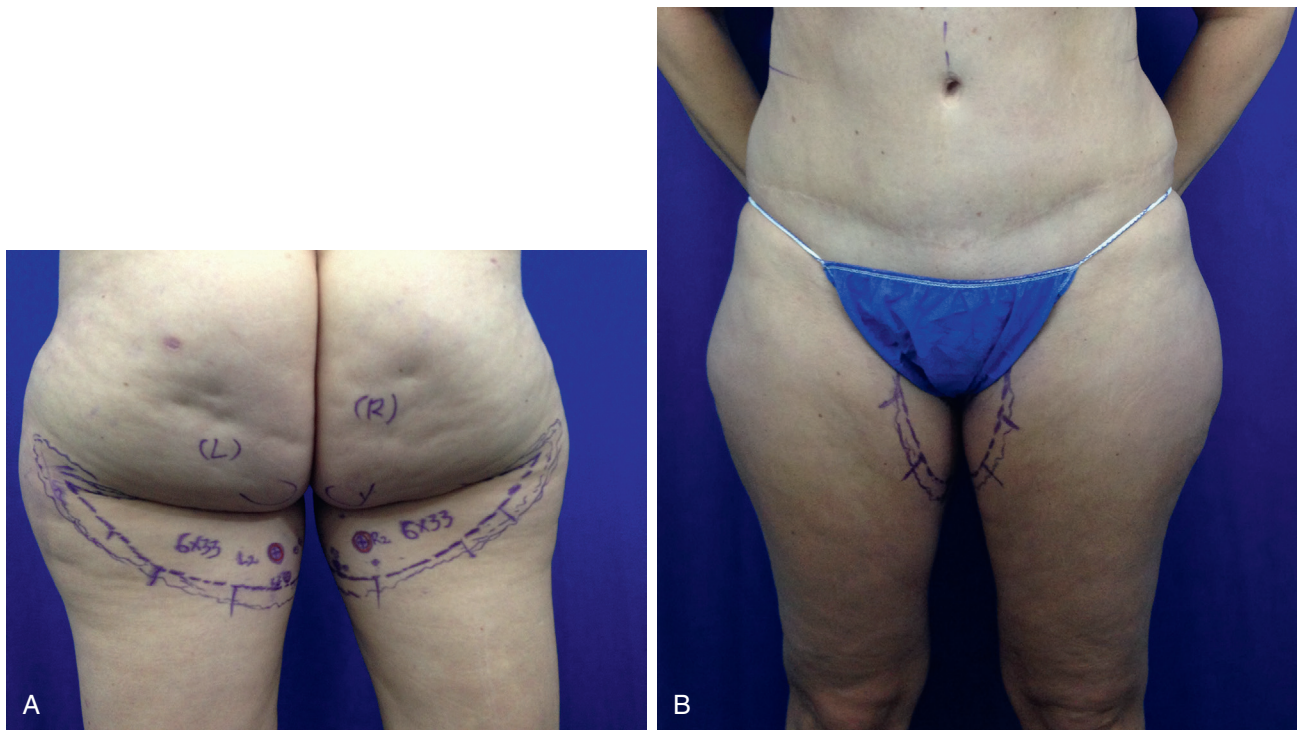
The VPAP flap perforators are identified using preoperative imaging. Their locations are confirmed using a handheld Doppler in the harvest position, which is typically lithotomy. The posterior edge of the gracilis muscle marks the anterior aspect of the flap. This allows for maximal versatility – in the event that the perforators are not adequate, the flap can be converted to a vertical gracilis muscle flap. The width of the skin paddle should not exceed 8 cm, but varies according to the patient-specific skin laxity (Fig. 6.3).

Flap Dissection

The patient is preferably placed in the supine “frog-leg” position or in lithotomy position. The lithotomy position is preferred for the vertical flap design dissection. For the transverse skin pattern dissection, the anterior aspect of the flap is first incised and the dissection then proceeds to the superficial fascia. In order to optimize volume, conservative beveling can be performed during the initial dissection. However, beveling superiorly should be limited, to avoid disturbing the inferior buttock and gluteal fold. The fascia is entered over the gracilis muscle. The latter is retracted anteriorly and the fascia of the adductor magnus is incised. The dominant perforator is identified usually 2–3 cm posterior to the gracilis muscle. The dissection is then continued using standard perforator dissection technique in order to harvest the desired pedicle length and vessel diameter, which occurs deep to the adductor magnus muscle. The pedicle measures approximately 10 cm in length and is approximately 2.3–2.7 mm in diameter.



• **Fig. 6.1** Preoperative imaging with magnetic resonance angiography (MRA) or computed tomography angiography (CTA) is advised for all patients to enable perforator mapping and dissection, and to decrease operative time. MRA also allows preoperative measurement of the fat pad.



• **Fig. 6.2** (A,B) Preoperative markings for bilateral transverse PAP flaps in a 44-year-old woman with a history of bilateral mastectomy following a diagnosis of poorly differentiated left-sided breast cancer.



• **Fig. 6.3** Preoperative markings. The adductor longus and gracilis muscles are marked with the elliptical site of planned VPAP flap harvest.

The vertical flap design is incised at the posterior edge of the gracilis muscle as described above and the dissection is continued without beveling the skin through the muscle fascia, and then the flap elevation is carried from anterior to posterior with the bipolar cautery. Once the

favorable perforator vessel is identified, dissection continues in the standard fashion to identify the profunda femoris vessels from which the pedicle is divided. The length of the pedicle is similar to the transverse design with approximately 10 cm in length and 2.3–2.7 mm in vessel diameter (Figs. 6.4–6.6).

Microvascular Anastomosis

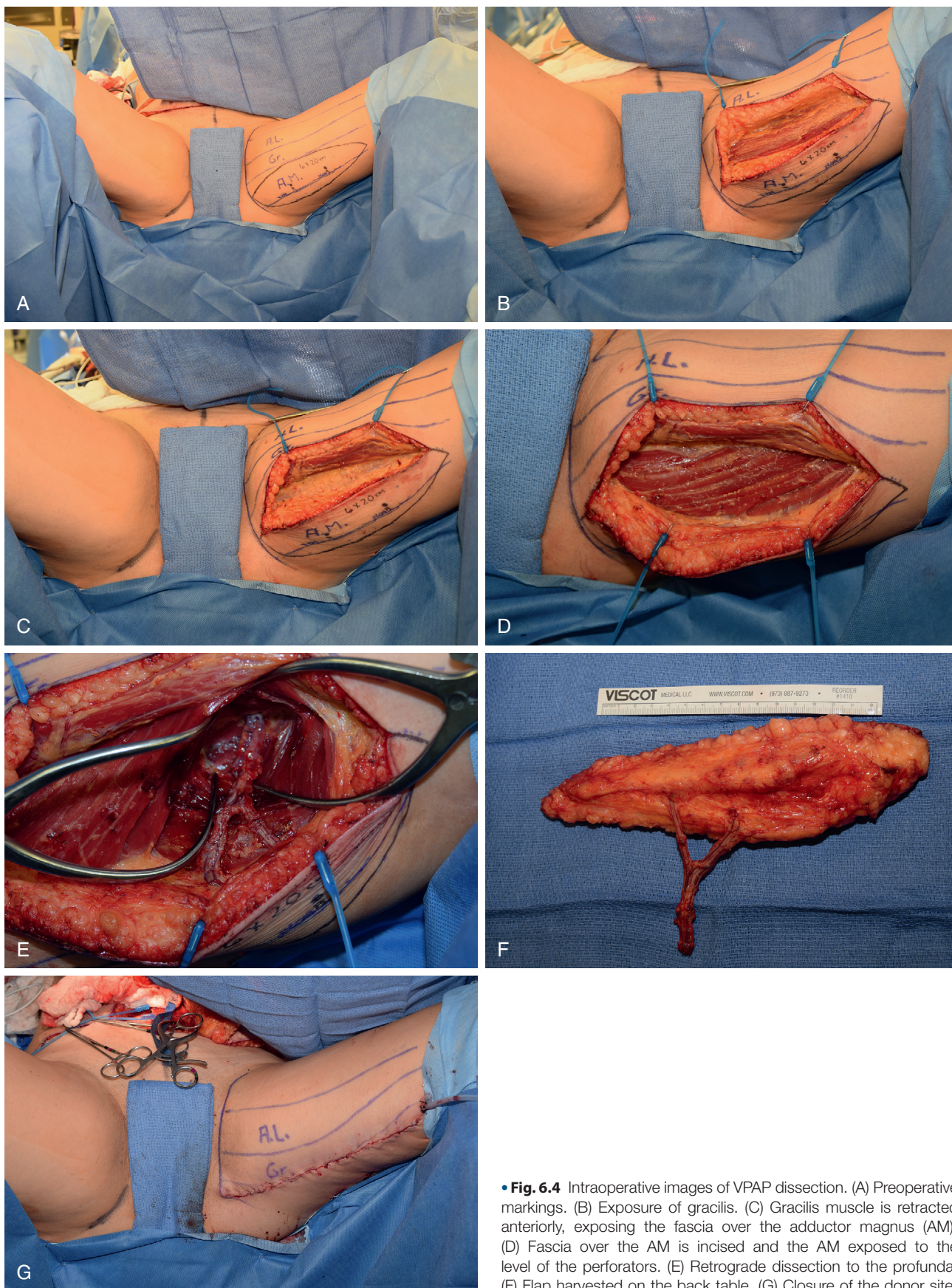
The arterial microvascular anastomosis is performed with 9-0 or 8-0 nylon suture in an interrupted or running fashion according to surgeon preference and vessel anatomy. The vein is usually anastomosed with a 2–3-mm coupler.

Flap Inset

The flap is inset in a transverse fashion and coned to form the breast. When combined with the DIEP flap in a stacked configuration it preferably sits inferiorly in the position of the inframammary fold to fill the lower pole of the breast. The flap(s) can then be de-epithelialized as needed and final inset performed.

Donor-Site Closure

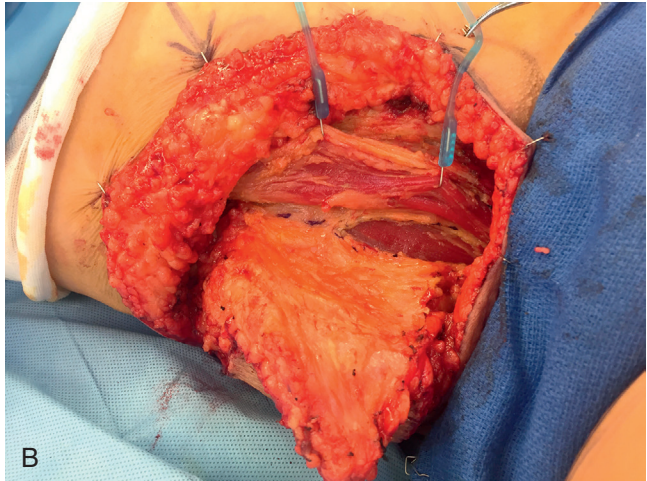
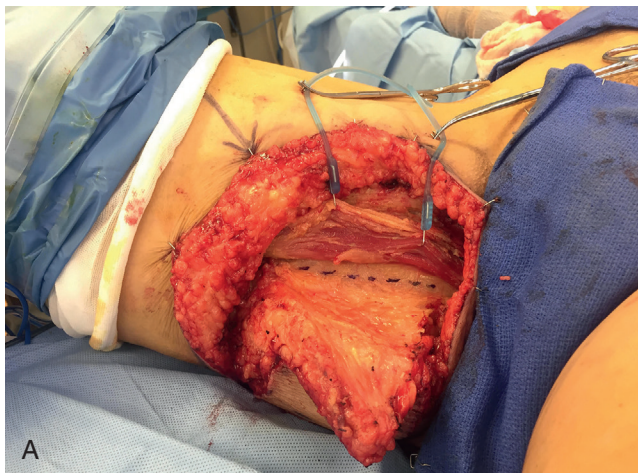
The donor site is closed in multilayer fashion over a closed suction drain and then a compression dressing is applied.



• **Fig. 6.4** Intraoperative images of VPAP dissection. (A) Preoperative markings. (B) Exposure of gracilis. (C) Gracilis muscle is retracted anteriorly, exposing the fascia over the adductor magnus (AM). (D) Fascia over the AM is incised and the AM exposed to the level of the perforators. (E) Retrograde dissection to the profunda. (F) Flap harvested on the back table. (G) Closure of the donor site.



• **Fig. 6.5** Stacked flap orientation in DIEP–VPAP combination. When using the PAP flap to complement the volume of a DIEP breast reconstruction, we prefer to use it in a stacked fashion, by placing it inferior to the DIEP flap, at the base of what will become the breast mound, anastomosing it to the mammary system in an antegrade fashion, and the DIEP to the retrograde mammary, respectively. Ensuring infra-mammary fold position before flap inset is an important step to allow for the flaps to fill the volume and contour of the reconstruction.



• **Fig. 6.6** (A–C) Intraoperative pictures of a transverse PAP flap dissection.

Case Examples

CASE 6.1

A 44-year-old patient with prior failed left gluteal artery perforator (GAP) flap for invasive ductal carcinoma of the left breast. The patient underwent prophylactic nipple-sparing

mastectomy of the right breast, removal of residual left GAP flap, and bilateral PAP flaps (Cases 6.1.1 & 6.1.2).



• Case 6.1.1

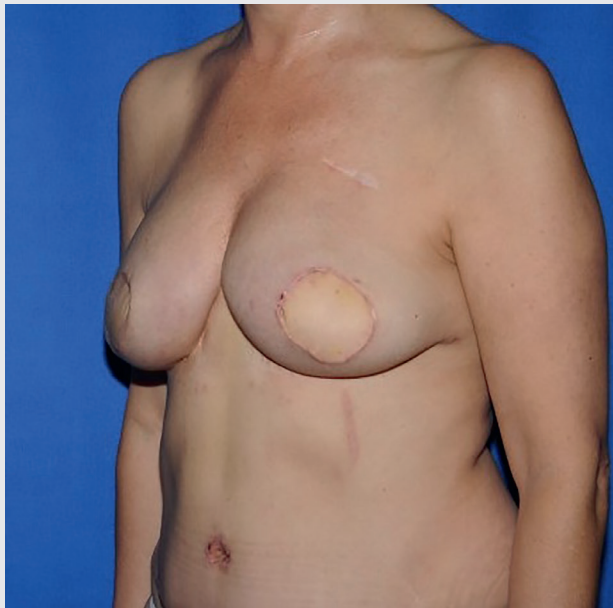


• Case 6.1.2

CASE 6.2

A 49-year-old patient with a history of several previous breast surgeries, including bilateral breast augmentation, revisional augmentation, and mastopexies, who presented for autologous reconstruction following a new diagnosis of left

breast invasive carcinoma with ductal and lobular features. Bilateral skin-sparing mastectomies with bilateral stacked DIEP-VPAP flaps were performed ([Cases 6.2.1 & 6.2.2](#)).



• Case 6.2.1

Continued

CASE 6.2—cont'd



• Case 6.2.2

Postoperative Care and Expected Outcomes

The postoperative care for patients undergoing the PAP flap is similar to that of any microvascular free tissue transfer procedure: postoperative flap monitoring for changes in color, texture, temperature, and capillary refill. The average hospital stay is usually 2–4 days.¹ Patients are able to ambulate on postoperative day one, the Foley catheter is removed, and the fluids are discontinued. It is recommended that softly cushioned seats and elevated toilet seats are used for 2–6 weeks to minimize discomfort in the thigh donor sites.¹ Patients are expected to recover for about two to three months. At that point, the patient is evaluated for revisional surgery. This could include correction of breast contour irregularities and volume issues as well as flap donor site scar irregularities or contour abnormalities. A secondary procedure is usually required to optimize the aesthetic outcome.

Management of Complications

The reported complications for the PAP flap are minimal, but like any microvascular free tissue transfer, there is a risk of vascular compromise and fat necrosis.¹ Other reported complications include donor site seroma, hematoma, and wound dehiscence.¹ Posterior thigh skin tightness and the possibility of neuropraxia are also possible in the transverse skin paddle design. The latter is avoided by preserving the posterior femoral cutaneous nerve if the dissection is performed in the suprafascial plane.¹ In our series, we have not

had total flap loss. The risk of fat necrosis is similar to what has previously been described for other breast free flaps.

The donor site is generally well tolerated. The most common donor-site complication is wound dehiscence. In our series, we have not encountered major wound dehiscence greater than 2 cm. Other possible complications include cellulitis, hematoma, and seroma formation. Particular to the transverse PAP design, patients have reported difficulties when sitting down for 4–6 weeks. There is occasional temporary loss of sensation in the posterior thigh, which recovers with time.

Secondary Procedures

The use of secondary procedures to improve breast contour and donor-site appearance is common in free flap breast reconstruction. Fat grafting to both the flaps and the recipient breast envelope is one of the most common secondary procedures. Other secondary procedures include nipple revision, skin island removal, and scar revisions, mainly of the donor site. Occasionally fat grafting has been used for augmentation when the flap is of insufficient volume.¹

Conclusions

The PAP flap is a secondary option for microsurgical breast reconstruction, which can be used alone or as a stacked procedure. It has proven to have consistent anatomy, and the use of preoperative imaging has contributed to its ease of dissection. The ability to identify perforators on imaging

has made flap dissection faster and more predictable and has decreased the complication rate of these microsurgical procedures. The PAP vessels are an excellent match for the recipient internal mammary or thoracodorsal vessels. The harvested tissue can be easily shaped to provide aesthetically pleasing breasts. The donor-site scar is usually well concealed and patients are able to mobilize early in the postoperative period. Another advantage with the PAP flap is that the procedure is now commonly done in the supine “frog-legged” position or with the patient in stirrups, which allows for a two-team approach, speeding up the operative time and requiring less anesthesia time for the patient. The PAP flap is an excellent option for microsurgical breast reconstruction as it has a long pedicle with good vessel diameter, can be naturally coned, and has a well-hidden donor scar. We recommend the PAP flap as an excellent alternative for microsurgical breast reconstruction when the abdomen is not available or when more volume is needed as a stacked flap.

PEARLS FOR SUCCESS

- The ideal patient is of thin body habitus with small breasts, in whom the abdomen is not a viable donor site.
- The PAP flap can have a vertical (VPAP) or a horizontal flap design.
- Preoperative imaging is of great importance for flap design planning and perforator dissection.
- Lithotomy or “frog-leg” positioning allows for flap dissection at the time of mastectomy.
- It is important to limit the beveling when dissecting the flap to avoid donor-site contour deformities.
- Vessel diameter is a good match for the internal mammary system.
- Pedicle length measures an average of 10 cm.
- The PAP flap is commonly used combined with other flaps to increase volume as a stacked flap.

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7

Free Transverse Upper Gracilis Flap Breast Reconstruction

RUDOLF F. BUNTIC

Introduction

The armamentarium available to both the plastic surgeon and breast reconstruction patient has continued to expand with improvement of techniques and the actual number of flaps and implant alternatives available. The transverse upper gracilis (TUG) flap provides just such an alternative. Although the deep inferior epigastric perforator (DIEP) flap is often the first choice for autologous breast reconstruction, not all patients are good candidates. Patients may lack abdominal tissue, have had previous abdominal surgery or desire to have excess tissue removed from a different donor area. Non-abdominal donor sites such as the superior gluteal artery perforator (SGAP), inferior gluteal artery perforator (IGAP), TUG and profunda artery perforator (PAP) can be considered. Each has unique characteristics and strengths that can be used to advantage, however drawbacks are not inconsequential for the SGAP, IGAP and PAP. Another free flap alternative, the TUG flap, provides an excellent breast reconstruction method in the appropriate patient. Among its many benefits, it has a reliable and straightforward pedicle dissection, good projection and an inconspicuous donor scar.

While some donor tissues can have tedious dissection, the TUG is based on the anatomy of the gracilis muscle and the surgical dissection and blood supply are consistent. The gracilis muscle is entirely expendable, and there are no significant functional changes with loss of the gracilis. And, unlike abdominal donor tissue, bulging or hernia formation are not a factor in TUG harvest.

While DIEP and superficial inferior epigastric artery (SIEA) flaps offer an aesthetic perk, i.e. they are similar to an abdominoplasty, the TUG donor area is based on the excess thigh tissue, fat or skin as it is designed for a medial thigh lift. This side benefit can nudge the patient and surgeon toward selection of this flap over others depending on patient body habitus.

The TUG flap can be used in both immediate and delayed reconstruction, with or without a skin paddle, and can be combined with later implant augmentation or fat grafting to increase size. In patients without a large amount of subcutaneous tissue, the potential for fat grafting or implant augmentation expands the indications of the flap. In addition, two TUG flaps can be stacked to enhance flap volume. Although flap stacking is more technically challenging, this can be an option in unilateral reconstruction patients who do not wish to have later augmentation or fat grafting.

Indications and Contraindications

All patients without inner thigh trauma or scarring are potential candidates for TUG flap reconstruction, providing they are free flap candidates. The flap is most commonly indicated in patients with insufficient abdominal tissue or prior abdominal surgery, such as abdominoplasty, liposuction or a failed abdominal flap. Patient preference is often an indication as well. It is not uncommon for patients to wish to avoid abdominal scars. Patients with small and moderate-sized breasts can be good candidates, with the typical patient being pear shaped, with excess medial thigh tissue, and in need of an A to B size cup (Fig. 7.1).

The TUG can be used in both immediate and delayed reconstruction of post-mastectomy deformity. If a free flap is being considered for a partial mastectomy irregularity, the TUG is an alternative. Patients with failed implants, chronic breast wounds or osteoradionecrosis can be considered as well. The placement of the gracilis muscle directly on any areas of osteoradionecrosis can be advantageous.

Like any microsurgical patient, the general health of the candidate should be considered. Advanced age, poor nutrition or underlying comorbidities can make this flap a poor choice. Peripheral vascular disease and possible gracilis pedicle disease can make the artery to the flap calcified.



• **Fig. 7.1** The “typical” TUG patient would have an excess of medial thigh tissue with enough to reconstruct at or near the patient’s preoperative breast size.

Morbidly obese patients are not good candidates. Because the patient is usually placed in the lithotomy position for flap harvest, positioning the morbidly obese patient may be impossible.

Absolute contraindications are a history of hypercoagulable disorder or bleeding diathesis that cannot be addressed with medical intervention. Previous inner thigh surgery that infringes on the vascular pedicle, perforators or flap design should be a warning to avoid this flap. Caution should be used in the patient with saphenous vein stripping. If a secondary vein is needed for accessory venous outflow (say, a poor internal mammary vessel), the surgeon may want to have the saphenous cutaneous vein available for microsurgical coaptation. The posterior branch of the saphenous vein can be a good second draining vein, similar to the superficial inferior epigastric vein in the DIEP flap. Any history of knee or hip arthritis or arthroplasty could be problematic. The patient should be able to have the hip flexed and knee flexed during the harvest of the flap, which is most commonly performed in the lithotomy position. Lack of joint flexibility can make intraoperative positioning difficult.

Preoperative Evaluation and Special Considerations

The evaluation of the TUG patient follows that of any microsurgical patient: a full history and complete exam are mandatory. Attention is paid to any history of lower extremity issues or lower limb surgery. Medial thigh contour, fat distribution and any excess skin are assessed with the patient

in the upright position. The upper medial thigh tissue is evaluated with a pinch test, examining both the laxity of the tissue and the amount of subcutaneous fat. Because the flap extends into the buttock crease posteriorly, this should be assessed as well. The entire lower extremity is examined for abnormalities, such as scar deformity, previous surgical sites, varicosities, asymmetry or edema.

The breasts and chest are examined to understand the potential volume match with the thigh. Is there enough medial thigh tissue to reconstruct the patient to their current size? If there is amastia, will the TUG provide enough of a skin paddle? The TUG is usually performed when volumes of 500 mL or less are needed, but as mentioned above, fat grafting or later augmentation under the flap can be performed. The potential for skin-sparing or nipple-sparing mastectomy is evaluated also. If the entire flap will not be de-epithelialized and the patient has hairy inner thigh skin, they may need later laser hair removal.

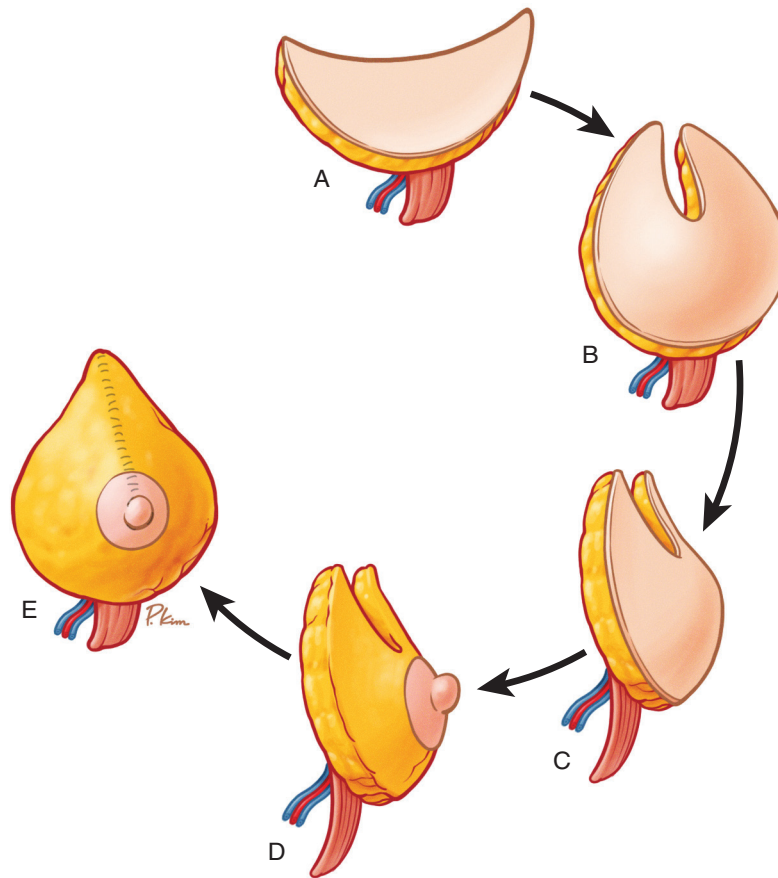
Although the risks of complete flap failure are small, consideration in the preoperative evaluation should be made in regard to what lifeboat surgeries the patient is a candidate for, in case of flap failure. Other free flap sources, such as the latissimus pedicled flap, or potential for implant reconstruction are evaluated by inspection and palpation.

If the patient is a TUG candidate, she should understand that the goal of the TUG reconstruction is to have a normal-appearing shape in clothing. Naked, in front of a mirror, there will be scars. If a unilateral reconstruction and donor area are planned, there will be thigh asymmetry postoperatively. The patient is counselled on this. In addition, lateral thigh fullness may be accentuated by medial thigh lifting. If that is the case, outer thigh liposuction might be considered at least three, but usually six months after reconstruction with the TUG. Patients are told a revision surgery, both in the reconstruction and donor area, may be necessary, just as in any breast reconstruction.

The unique design of the TUG donor area provides for natural flap folding and aesthetically pleasing breast shaping (Fig. 7.2).¹ In contrast to the DIEP or SIEA flap, the coned TUG flap provides improved projection, rather than the flat contour that can be characteristic of abdominal tissue breast reconstruction. Likewise, the TUG design and natural medial thigh donor skin color lend to immediate nipple-areola complex (NAC) reconstruction in some patients. The aesthetics of the TUG NAC are superior to tattooing with local nipple flap creation.

The risks of microsurgery, such as infection, bleeding, clotting, and delayed wound healing are covered in the preoperative evaluation. The patient should understand that closed suction drainage will be needed, and usually is in place for a minimum of two to three weeks. Seroma formation is possible and closed suction for a prolonged period helps minimize this issue.

Preoperative imaging of the donor area is not typically performed. The consistent blood supply of the TUG obviates the need for such an evaluation, unless the surgeon has a specific targeted question.



• **Fig. 7.2** The crescent of the flap is shaped by folding the superior edges together. The skin can be de-epithelialized to make an immediate nipple–areola reconstruction. (Courtesy of microsurgeon.org)

Surgical Techniques

Relevant Surgical Anatomy

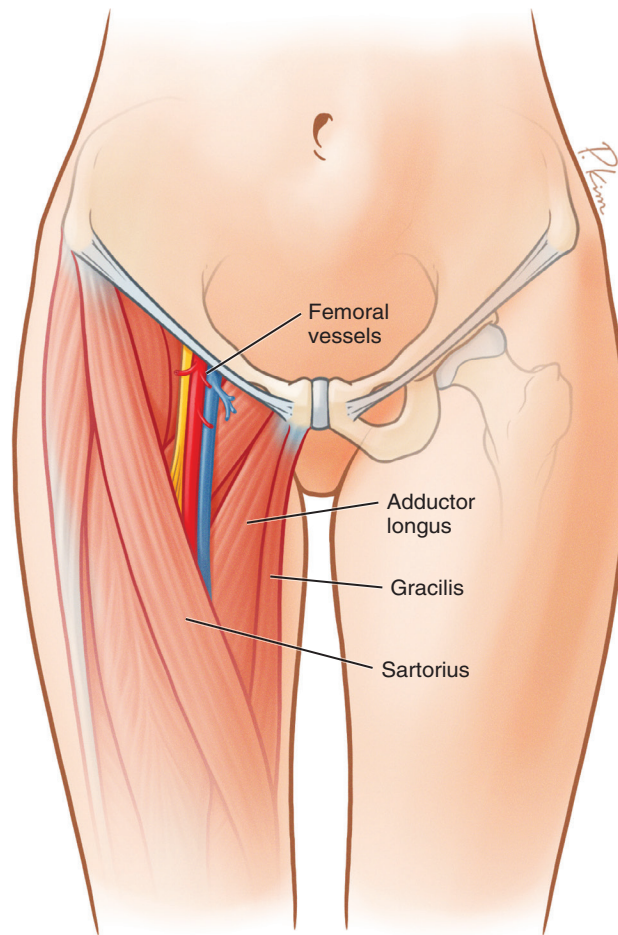
The gracilis muscle lies medially deep to the fascia lata of the thigh. The muscle belly runs posterior to the adductor longus and sartorius muscles and anterior to the hamstrings (Fig. 7.3). It arises from the ischiopubic ramus and inserts on the medial tibial tuberosity as the middle component of the pes anserinus.

The dominant vascular pedicle is located 8–10 cm distal to the pubic tubercle and travels between the adductor longus and on the surface of the adductor magnus to reach the deep aspect of the gracilis muscle (Fig. 7.4). The single artery and venae are at an almost right angle to the muscle axis. Secondary vascular pedicles are found distal to the dominant vessel, but these are not adequate to support the flap. Musculocutaneous perforators nourish the overlying skin with a transversely oriented perforasome centered over the proximal third of the gracilis muscle.^{2,3} A branch of the obturator nerve supplies the motor innervation of gracilis. The nerve enters the muscle proximal to the pedicle and at an oblique angle.

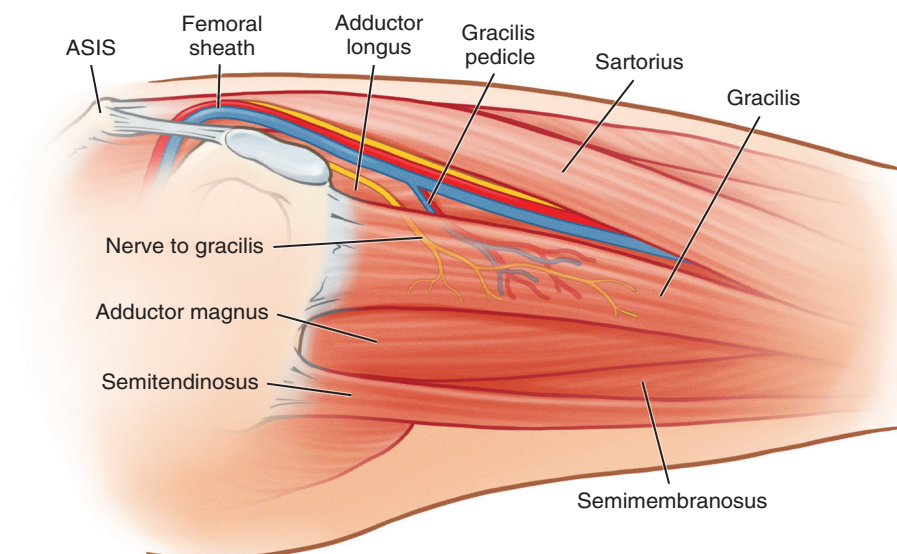
Preoperative Marking

The patient is marked in the preoperative holding area the day of surgery or the night before, in the upright position, using a pinch test to assess the extent of resection. The thigh markings are completed in the operating room. With the thigh abducted and the knee flexed the adductor longus is palpable, while with the knee extended the gracilis is palpable. The outline of the gracilis is marked and Doppler signals over the upper gracilis are found (Fig. 7.5). The crescent shape of the flap can be adjusted to capture the gracilis perforators as necessary.

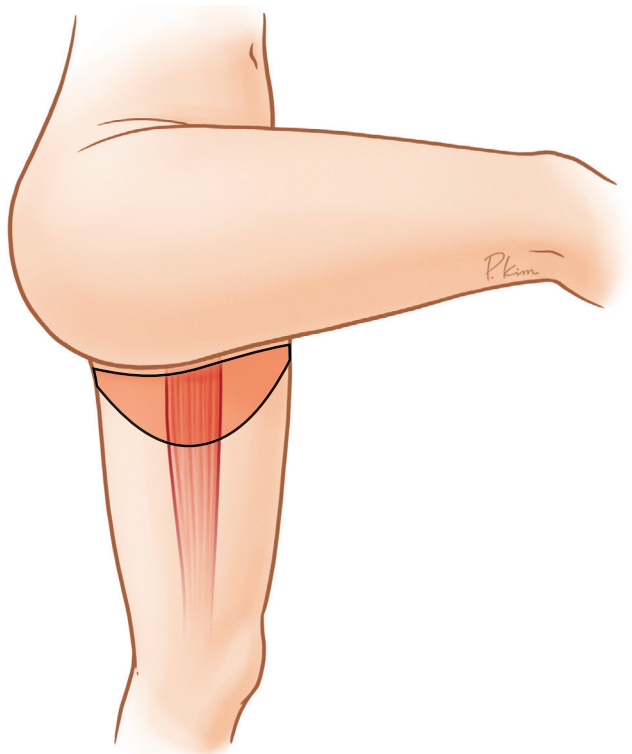
The incision drawings are made in a crescentic fashion, with the upper line approximately 1–2 cm below the inguinal crease on the axis of the gracilis (Fig. 7.6). The flap is marked in the inner thigh crease, just below the inguinal ligament, extending posteriorly in the inferior buttock crease. The widest point of the flap skin paddle is centered over the gracilis muscle. The skin paddle is ideally 8–12 cm wide, as closure under excessive tension can result in donor-site breakdown, scar widening and labial spreading. An under anesthesia pinch test of the inner thigh in the adducted position helps confirm the extent of skin that can



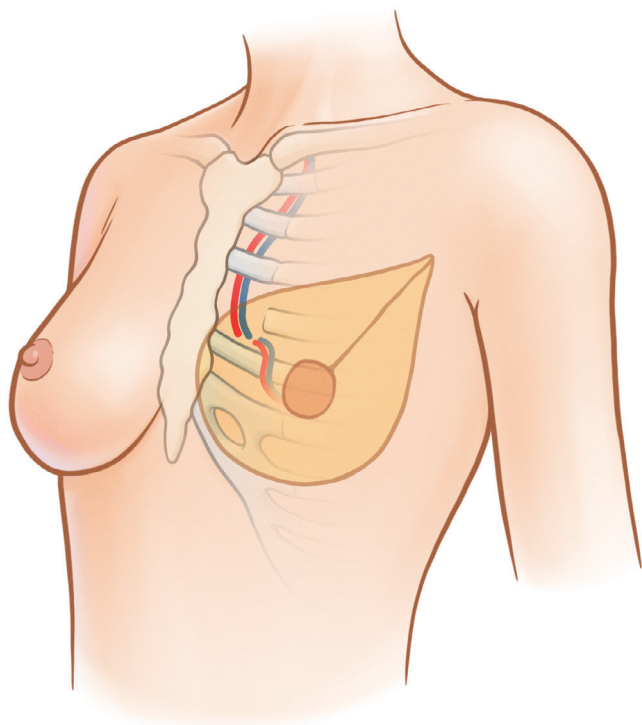
• **Fig. 7.3** The gracilis muscle is located in the medial thigh, running posterior to the adductor longus muscle. It is superficial to the adductor magnus. (Courtesy of microsurgeon.org)



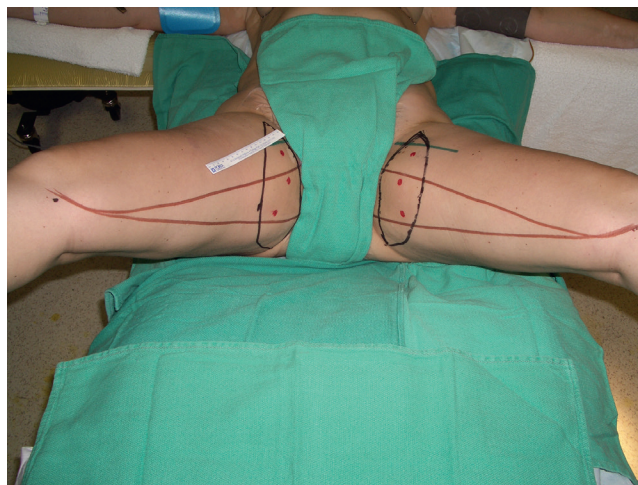
• **Fig. 7.4** With the patient supine and the hip flexed, the pedicle of the gracilis muscle enters the muscle on its deep surface at near 90 degrees. It enters the muscle about 8–10 cm distal to the pubis. The pedicle arises from the profunda femoral system. The nerve enters proximal to the pedicle. ASIS, anterior superior iliac spine. (Courtesy of microsurgeon.org)



• **Fig. 7.5** The design of the flap is centered over the long axis of the gracilis, and transverse to the muscle. (Courtesy of microsurgeon.org)



• **Fig. 7.6** The flap is oriented with the apex toward the axilla and the pedicle is anastomosed to the internal mammary vessels under the 3rd or 4th costal cartilage. (Courtesy of microsurgeon.org)



• **Fig. 7.7** Bilateral TUG flaps marked preoperatively. The perforators are marked over the gracilis with a pencil Doppler.

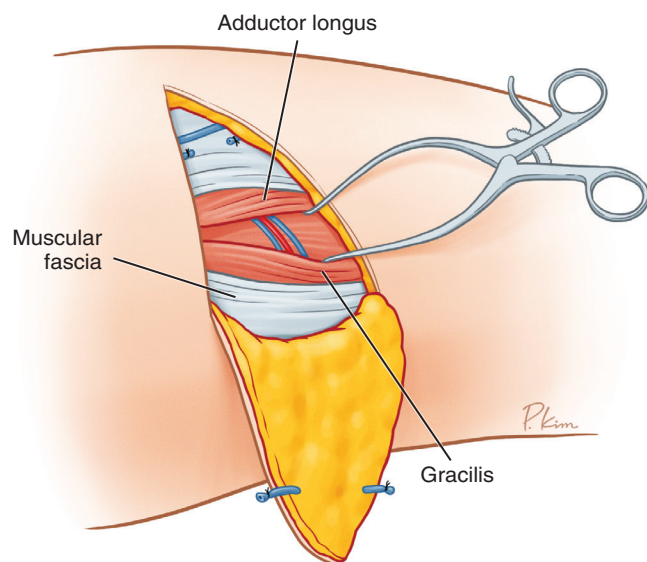
be removed. The anterior extent of the incision should not exceed the adductor longus by more than 2–3 cm.⁴ This hides the donor scar in the gluteal crease while avoiding an excessive and obvious anterior scar while minimizing the dissection in the femoral triangle – potentially decreasing the risk of lymphatic disruption.

Flap Dissection

The harvest is performed in the lithotomy position, allowing adequate access to the posterior incision (Fig. 7.7). The anterior flap is elevated first in a plane superficial to the muscular fascia of the adductor longus, sparing the anterior branch of the saphenous vein. The posterior branch of the saphenous vein travels through the anterior flap and is ligated and divided. At the medial aspect of the adductor longus, the muscular fascia is incised, and the dissection is carried onto the muscle. The pedicle to the gracilis is identified by retracting the adductor longus laterally (Fig. 7.8). This is best performed with the patient relaxed with a paralyzing agent administered by anesthesia. Once the pedicle is identified, the anterior edge of the gracilis can be seen. The flap must not be separated from the gracilis muscle. The muscle is found at the distal (inferior) aspect of the skin paddle and then the posterior axis of the gracilis is identified. The posterior flap can then be elevated safely.

The posterior flap is elevated just superficial to the deep muscular fascia, and then connects to the tissue deep to the gracilis at the posterior border of the gracilis. The proximal and distal gracilis muscle are divided. The pedicle is traced to its origin by placing self-retaining clamps between the adductor longus and magnus, exposing the areolar plane of the vascular leash. The artery and veins can be traced for usually not more than 6 cm to their origin. Two venae comitantes accompany the artery, one typically larger in diameter than the artery. The artery is usually 1–3 mm in size and typically smaller than the internal mammary artery.

The skin paddle can be assessed for perfusion and the flap can be tacked into the donor area while the recipient area is prepared. When the recipient area is ready, the flap vessels are ligated and divided (Fig. 7.9) and the flap is shaped on the chest.



• **Fig. 7.8** The anterior flap is elevated superficial to the muscular fascia. The fascia is entered at the posterior edge of the adductor longus. The space between the adductor longus and gracilis is retracted with a self-retaining retractor to expose the pedicle. (Courtesy of microsurgeon.org)

Donor-Site Closure

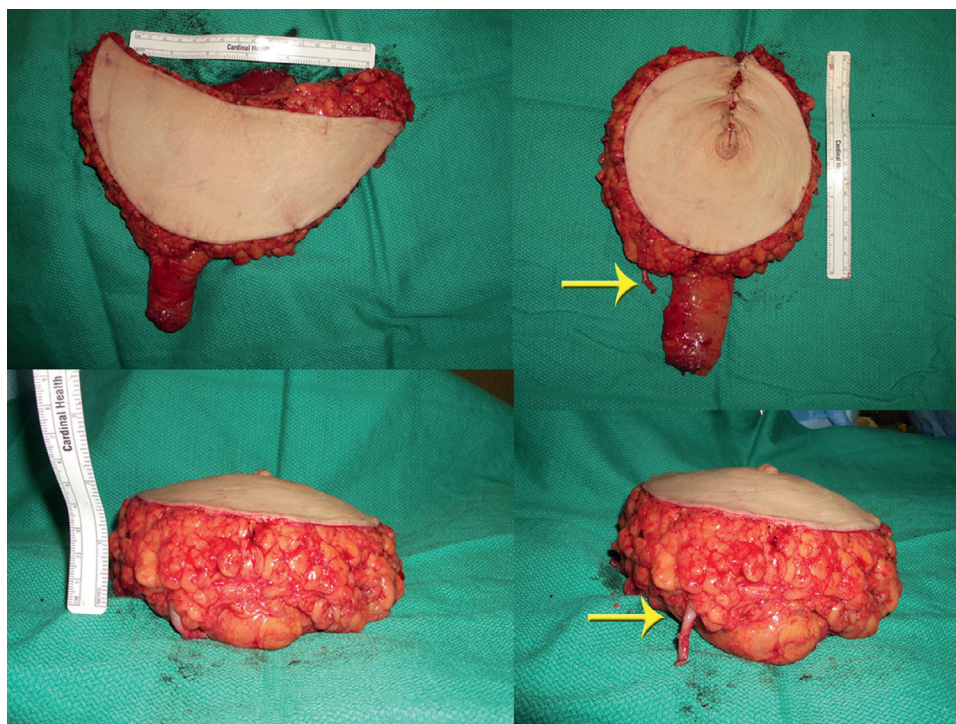
The donor site is closed by adducting the thigh. This requires adjustment of the lithotomy stirrups. The deep layer is closed with fascial interrupted sutures and then the skin closed in layers over a suction drain. Absorbable sutures are used, since non-absorbable suture can be difficult to remove in this area.

Flap Shaping and Inset

The flap is shaped (Fig. 7.10) by folding the crescent tips to each other and securing the folding with deep sutures.



• **Fig. 7.9** Bilateral TUG flaps harvested, and tacked in place on the medial thigh.



• **Fig. 7.10** The flap is harvested and shaped. Note the posterior saphenous vein branch (yellow arrow).

The folding results in a standing cone that mimics breast projection. De-epithelialization proceeds and the NAC can be fashioned by leaving skin centered over the apex of the fold. The naturally darker color of the inner thigh compared to the relatively pale breast skin color gives the NAC a nice contrast in color (Fig. 7.11). The flap can be completely de-epithelialized if in nipple-sparing mastectomy, partially de-epithelialized in skin-sparing mastectomy, or the entire skin paddle can be used if necessary.



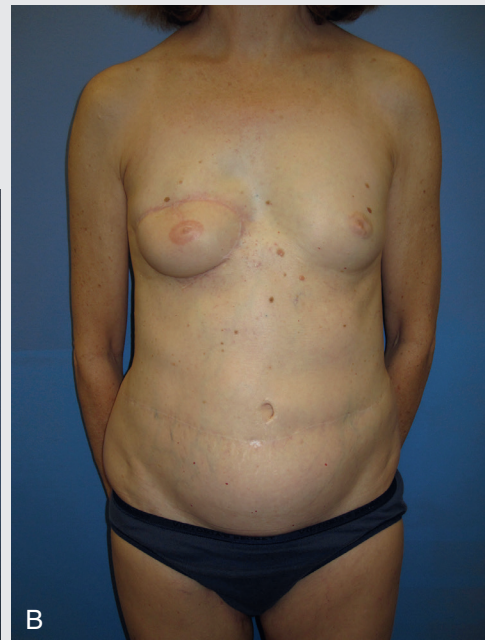
• **Fig. 7.11** The flap is de-epithelialized to the extent desired. An immediate NAC is formed in this case and mimics the breast quite nicely.

Case Examples

CASE 7.1

A patient with failed transverse rectus abdominis myocutaneous (TRAM) flap, radiation and a chronic wound of the right chest (Case 7.1.1A) presented for breast reconstruction. An ipsilateral TUG reconstruction was performed with large skin paddle

and later nipple–areola tattooing. The result at one year shows good symmetry with the contralateral side (Case 7.1.1B). High asymmetry is not particularly prominent. The patient desired no other revision surgery.



• Case 7.1.1

CASE 7.2

A patient with a history of breast cancer presented for bilateral mastectomy ([Case 7.2.1A](#)). She had a paucity of abdominal tissue relative to the thighs. Bilateral TUG reconstructions were performed with nipple–areola reconstruction using the apex of the de-epithelialized TUG flaps. She is pictured in [Case 7.2.1B](#)

at approximately 6 months after reconstruction. Note the excellent projection and color of the TUG, which mimics the preoperative shape of the breast quite well. There has been no revision surgery.

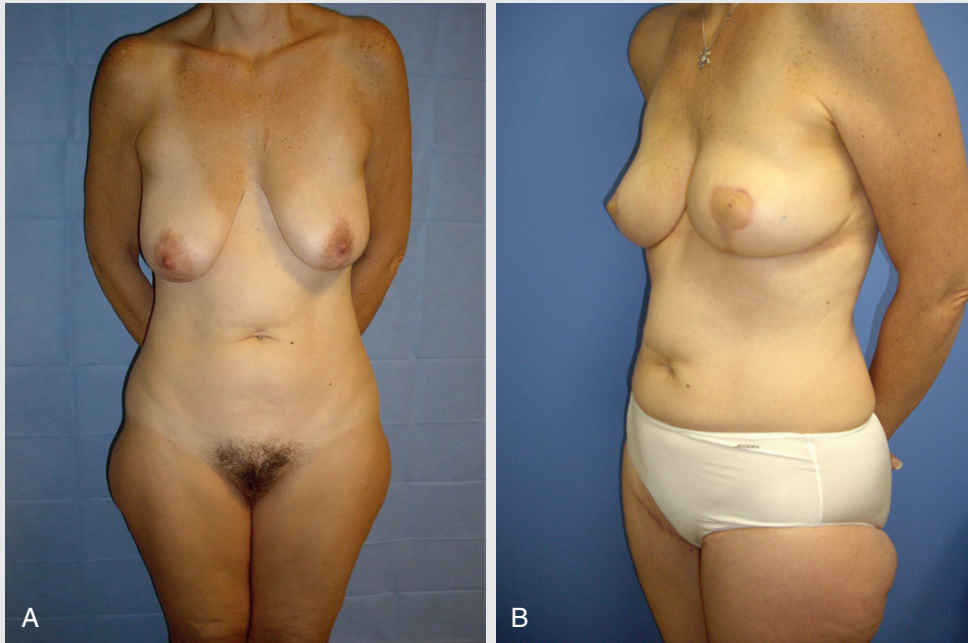


• Case 7.2.1

CASE 7.3

A 65-year-old presented for bilateral mastectomy after cancer ([Case 7.3.1A](#)). Immediate reconstruction with bilateral TUG flaps was performed, since the patient had little abdominal tissue. The oblique image shows the excellent projection of the breast and nipple–areola complex ([Case 7.3.1B](#)). A Wise

pattern type incision was used for mastectomy to allow re-draping of the skin envelope. But the good nipple projection is not due to the mastectomy skin pattern, rather the intrinsic characteristics of the folded TUG flap.

CASE 7.3—cont'd

• Case 7.3.1

CASE 7.4

A 58-year-old with history of bilateral breast reconstruction with SGAP flaps after failed DIEP flaps complained of the shape of her left breast. The left SGAP had partial loss of the flap ([Case 7.4.1A](#)), resulting in inferior pole loss. She was unsatisfied with the contour in clothing and requested TUG reconstruction. Vein grafting of the flap was performed to the external jugular

vein with a saphenous vein graft to the vein of the TUG flap and yielded a good result ([Case 7.4.1B](#)). The patient had the internal mammary and axillary system used in previous microsurgical reconstructions. The internal mammary artery was used again, but the internal mammary vein was not usable.



• Case 7.4.1

Postoperative Care and Expected Outcomes

Pressure dressings are taped onto the donor-site incisions and the patient is initially placed on bed rest. The patient avoids abducting her legs for several days, at which point the tension on the incision site begins to relax. The patient resumes recovery similar in fashion to any microsurgical patient.

Suction drains are kept in until less than 30 mL per day drainage. The drains are usually needed more than two weeks, and often more than three. If the drains need to be removed early, the medial thigh is observed for seroma formation and any seroma collection is evacuated by needle aspiration during patient follow-up.

A thigh girdle is optional. We have found it is not necessary to avoid seroma.

Patients can re-start exercise activity at about 6 weeks, and resume all normal activity by about three months.

The rate of total flap failure for the TUG flap ranges from 2% to 6%, while partial flap loss is similar. Donor-site morbidity for the TUG flap is generally acceptable to patients and microsurgeons, and provides a good alternative to patients who seek autologous reconstruction.⁵

Management of Complications

Microsurgical thrombosis in the hospital postoperative period is typically handled by re-exploration and anastomotic repair. Venous outflow issues can sometimes be addressed by augmenting venous outflow with the posterior branch of the saphenous vein that is included in the flap.

Contour deficits can be addressed with secondary fat grafting. The outer donor thigh is a good area for fat harvest as it is relatively full compared to the postoperative medial thigh.

Donor site complications include seroma (7%), wound breakdown/scar revision (6%), and sensory disturbances (4%).⁶ Limiting the flap width to less than 10 cm reduces the dehiscence and infection rate. Donor-site wound dehiscence is usually managed with secondary healing and dressing changes.

Secondary Procedures

Like any breast reconstruction secondary revision surgery is frequent. Unilateral reconstruction patients may require symmetry procedures, such as fat grafting the flap, augmentation underneath the flap, or contralateral breast surgery. If a large volume of gracilis muscle is harvested at the initial flap procedure, atrophy of the muscle may cause a decrease in size of the breast. In one series the average number of additional procedures per patient (not including NAC reconstruction) is as high as 3.9 (SD 2.9).⁷

Revision surgery is usually done at approximately 6 months postoperatively from the time of flap reconstruction. This allows some time for flap and donor area swelling to subside. Certainly the scars are not fully mature at

this time, but patients often wish to move along in their reconstruction by this time.

Conclusions

The TUG flap is an excellent alternative of other free flap microsurgical reconstructions. Dissection is straightforward, the anatomy is consistent, and surgical harvest time is expeditious. The flap has intrinsic properties that allow for excellent shaping and projection. The inner thigh skin paddle can create an aesthetically pleasing nipple–areola reconstruction. It can be considered in any patient who is a microsurgical candidate for breast reconstruction. It is however, best in patients with small to medium-sized requirements, and adequate inner thigh donor tissue.

PEARLS FOR SUCCESS

- The blood supply to the flap is via the artery and venae to the gracilis muscle, and relies on perforators from the gracilis to the overlying skin.
- The flap is best in:
 - Patients with small to medium-sized breasts
 - Patients with adequate inner thigh tissue
 - Candidates for microsurgery.
- The flap is harvested with the patient supine, in the lithotomy position.
- The ipsilateral or contralateral flap can be used (although we most often use the contralateral flap).
- The flap is usually anastomosed to the internal mammary vessels.
- The flap can be augmented with secondary fat grafting or implants after an adequate healing period.

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8

Latissimus Dorsi Flap Breast Reconstruction

JASSON ABRAHAM AND MICHEL SAINT-CYR

Introduction

The latissimus dorsi (LD) flap is a reliable option for primary autologous breast reconstruction and for salvage of failed prior breast reconstruction because of its robust perfusion, consistent vascular anatomy, and concealable donor site scar. However, the traditional LD flap is limited by its volume, and often requires augmentation with either an implant, additional autologous tissue flaps, or fat grafting to obtain the desired shape and volume.

Hokin et al, first described the use of an extended LD (ELD) flap, which incorporated lumbar fat to increase flap volume.¹ In an attempt to avoid using a breast implant, modifications of the ELD by harvesting the entire LD muscle, lumbar fascia, and a large skin paddle have been performed. However, it has been associated with increased morbidity, with risks of wound breakdown, skin necrosis, seroma formation, and significant contour deformities of the back.

Advancements in surgical techniques with the use of progressive tension sutures, quilting sutures, and fibrin sealants to obliterate potential space at the LD and ELD donor sites have decreased rates of seroma formation.² (Videos 8.1 and 8.2 demonstrate progressive tension sutures and quilting sutures technique. Video 8.2 demonstrates the obliteration of empty space after performing quilting sutures at the donor site). Furthermore, a greater appreciation of the different fat compartments in the back has limited fat harvest to the thoracolumbar and lumbar compartments, thereby optimizing the contour of the back after flap harvest. The selective harvest of these fat compartments provides the patient with an ideal “hourglass” figure, while avoiding the disfigurement associated with parascapular fat harvest, and the fat necrosis with harvest of the distal suprailiac fat.³ The most versatile tool in volume augmentation and for the correction of contour deformities has been the incorporation of fat grafting of the mastectomy site

and the LD flap.³ Fat grafting can be performed at the time of LD breast reconstruction or as an adjunct procedure during secondary breast reconstruction revision. (Video 8.3 demonstrates intraoperative fat grafting of the LD flap.) Other modifications of the LD flap for breast reconstruction include the endoscopically harvested LD, muscle-sparing LD, and the thoracodorsal artery perforator flap (TDAP).

Indications and Contraindications

The LD flap with fat grafting or with an implant can be an excellent choice for primary reconstruction or for salvage of a previously failed reconstruction.

Please see [Box 8.1](#) for inclusion criteria regarding use of LD flaps for breast reconstruction. We prefer to use the LD flap in combination with fat grafting (without implants) in patients with the following characteristics:

1. Patient not a candidate for free flap–based breast reconstruction
2. Previous radiation therapy (XRT)
3. High BMI (BMI >35–40 kg/m²) patients
4. Co-morbidities which preclude long surgical procedures
5. Conversion of implant-based reconstruction in non-free flap candidates.

Larger breasts can be reconstructed with the augmentation of the LD flap or by harvesting an ELD. The ability to perform fat grafting at the initial reconstruction can help avoid the use of an implant, keeping the reconstruction entirely autologous. The robust vascularity of the flap introduces healthy soft tissue in previously irradiated areas, and can provide excellent soft tissue coverage for implants. There are very few contraindications for the flap, which include:

1. Previous history of posterolateral thoracotomy⁴
2. Previous injury to the thoracodorsal pedicle and nerve
3. Inadequate soft tissue volume at the donor sites (including LD donor site and fat graft donor site).

• BOX 8.1 Inclusion Criteria for LD-Based Breast Reconstruction

- Inadequate abdominal soft tissue (skin and fat).
- Prior abdominal surgery with contraindication for abdominal-based reconstruction (abdominoplasty or previous abdominal-based reconstruction).
- Medical co-morbidities with “high risk” of complications with prolonged surgical procedures, including personal history of pulmonary embolism or deep vein thrombosis with positive thrombophilia screen.⁸
- Patient with small to moderate breast volume with standard LD.⁸
- Patient with large breast volume in high-BMI patients with ELD and fat grafting.
- Patient’s personal preference.
- Prior radiation therapy for breast conservation therapy and not candidate for a free flap.

Preoperative Evaluation

Patient History

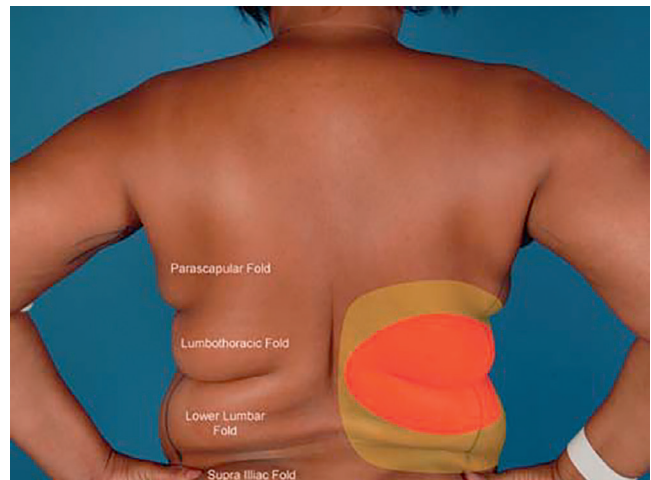
During the preoperative consultation, the patient’s medical history is critically evaluated for their surgical candidacy. This should always include documentation of surgical history, history of nicotine use, cardiopulmonary health status, personal and family history of coagulopathy, therapeutic use of antiplatelet or anticoagulation therapy, history of general anesthesia associated complications, and body mass index (BMI). A complete breast history should be obtained, including prior breast surgeries (aesthetic and reconstructive), planned tumor extirpation method (nipple-sparing vs skin-sparing vs simple mastectomy), prior or planned axillary lymph node dissection, and plan for adjuvant therapies. Women undergoing delayed breast reconstruction are considered better surgical candidates as they have completed all planned adjuvant therapy, have been disease-free for a period of time, and are at a lower risk for infection, hematoma, and mastectomy skin flap necrosis.⁴

Physical Examination

A thorough physical examination involves evaluating the involved breasts for surgical scars, presence or absence of the nipple–areola complex, radiation-related skin changes and surrounding tissue quality, and relative symmetry with the contralateral breast. The abdomen, flanks and lower extremities should be examined as possible donor sites for free tissue transfer or fat grafting. The soft tissue of the back is evaluated with a “pinch” test to determine the amount of tissue which can be safely harvested without undue tension on donor-site closure (Fig. 8.1). The thoracolumbar and lumbar fat compartments are readily identified by having the patient flex in the ipsilateral direction to create the natural intercompartmental creases (Fig. 8.2). A pinch test can identify the most natural crease for the skin paddle



• **Fig. 8.1** Photograph demonstrating the double-bubble pinch test. This test demonstrates the incorporation of the lumbosacral and lumbar folds (red and purple) within the skin paddle design. Both folds are pinched together. In the double-bubble pinch test, the size of the fat compartment can be estimated, as can the ability to close the donor site primarily. The majority of the undermining is performed cranially over the descending branch of the thoracodorsal artery to capture as many perforators as possible and maximize flap perfusion. Harvesting the largest skin paddle with double fat compartments avoids having to undermine aggressively and helps limit dead space and seroma formation. (Reproduced from Saint-Cyr M, et al. The low transverse extended latissimus dorsi flap based on fat compartments of the back for breast reconstruction: anatomical study and clinical results. *Plast Reconstr Surg.* 2011;128:382e, Figure 9.)



• **Fig. 8.2** Photograph showing the fat compartments related to the latissimus dorsi flap on the patient’s left side. Note the design of the extended latissimus dorsi skin paddle in red and the areas of fat harvest noted in yellow. Maximal volume can be obtained by incorporating two soft tissue rolls or fat compartments within the skin paddle design. (Reproduced from Saint-Cyr M, et al. The low transverse extended latissimus dorsi flap based on fat compartments of the back for breast reconstruction: anatomical study and clinical results. *Plast Reconstr Surg.* 2011;128:382e, Figure 8.)



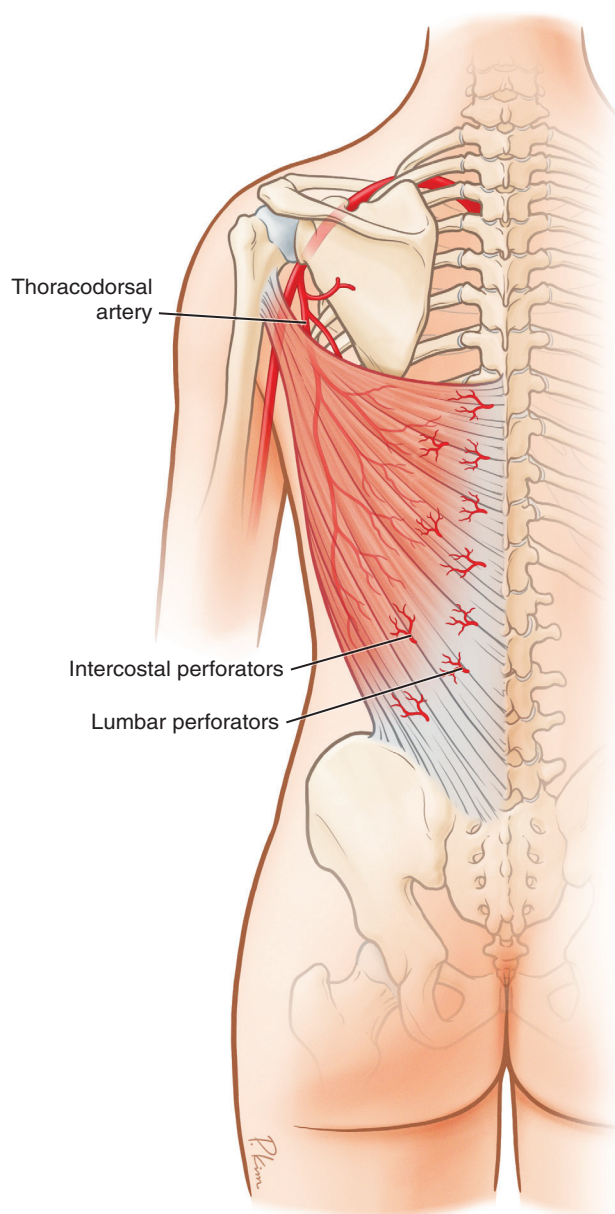
• **Fig. 8.3** Postoperative view of the donor site demonstrates a well-healed scar, easily concealable underneath the bra strap.

design along the ipsilateral back. The orientation of the skin paddle is designed as needed to match the soft tissue deficit at the mastectomy site. A horizontal skin paddle designed at the low or mid-back results in a well-positioned final scar, hidden within the bra line, and has the highest reported patient satisfaction⁵ (Fig. 8.3). Positioning the skin paddle main axis along a natural tissue crease in the back (usually horizontal or horizontal-oblique) will not only allow for a larger skin paddle harvest, but will also facilitate closure.

The functionality and anterior border of the LD muscle is verified by forceful adduction of the arm against the examiner's hand. This maneuver demonstrates the integrity of function of the LD, and helps identify the anterior border of the muscle. Digital palpation can identify the anterior groove or border of the LD muscle, and the true anterior border of the LD muscle is usually marked 1–2 cm anterior to the palpated groove. The patient should be informed that muscle harvest can occasionally result in weakness with pulling and overhead activities, which might require postoperative physical therapy to help strengthen the shoulder muscles and to improve the range of motion.

Surgical Anatomy

The LD muscle is a Mathes and Nahai type V muscle with a dominant thoracodorsal (TD) artery and secondary segmental blood supply from lateral perforators of the lumbar arteries, and from medial perforators of the intercostal arteries. The pedicle is approximately 8 cm long and with a 2–3-mm arterial diameter. The artery bifurcates into the descending and transverse branches, approximately 5 cm inferior to the posterior axillary line.⁶ The descending branch is the dominant branch of the thoracodorsal artery and has larger perforators than the transverse branch, and is the pedicle for the muscle-sparing LD flap (Fig. 8.4).



• **Fig. 8.4** Vascular anatomy of the latissimus dorsi muscle. The muscle is primarily supplied by the thoracodorsal vessels with secondary perfusion from perforators of the lumbar arteries and intercostal arteries. (Adapted from Gart M, et al. Latissimus dorsi flap breast reconstruction. In: Nahabedian MY, Neligan PC, eds. *Plastic Surgery*. 4th ed. Vol 5. © 2018, Elsevier Inc.)

The four major fat compartments of the back are the parascapular, thoracolumbar, lumbar, and suprailiac fat compartments (Fig. 8.5: 2, 3, 4, and 5, respectively). The parascapular fat compartment is superficial to the scapula, and extends inferiorly to the level of T5. This compartment is left intact to avoid postoperative contour deformities. The entire thoracolumbar and lumbar fat compartments are harvested for breast reconstruction with an extended latissimus dorsi flap. The thoracolumbar fat compartment is immediately inferior to the parascapular compartment, and lies between T7 and T10 medially, and the inframammary fold



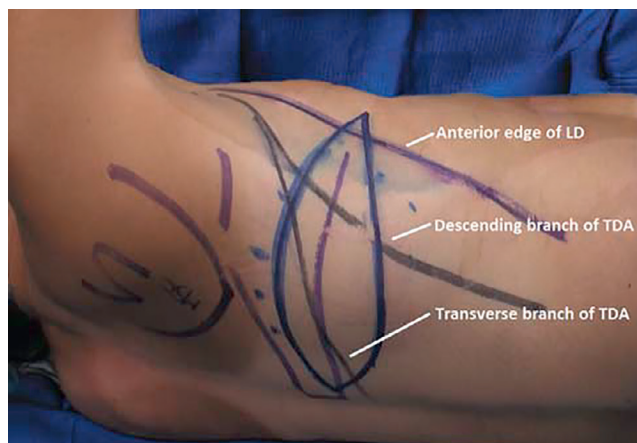
• **Fig. 8.5** Photograph demonstrating the spread of the dye in the subcutaneous fat compartments of the back. Note that the dyes do not mix at the borders, as they are limited by the fibrous septa, which separate the fat compartments. (Reproduced from Saint-Cyr M, et al. The low transverse extended latissimus dorsi flap based on fat compartments of the back for breast reconstruction: anatomical study and clinical results. *Plast Reconstr Surg.* 2011;128:382e, Figure 4.)

laterally. The lumbar fat compartment is inferior to the thoracolumbar fat compartment and lies between T11 and L4 medially, and to the superior border of the iliac crest inferiorly. The suprailiac fat compartment lies superficial to the iliac crest and can extend up to 5 cm into the gluteal region, but dissection of this compartment is avoided due to potential distal flap fat necrosis (see Fig. 8.5: 5). For the purpose of this chapter, the LD flap design and harvest do not incorporate any additional fat compartments except for a moderate amount of subcutaneous tissue cephalad to the skin paddle and overlying the descending branch of the LD muscle. This is done to harvest as many perforators along the descending branch as possible. Immediate fat grafting will serve to provide additional volume without the risks of harvesting additional fat compartments, as seen in the traditional extended LD flap.

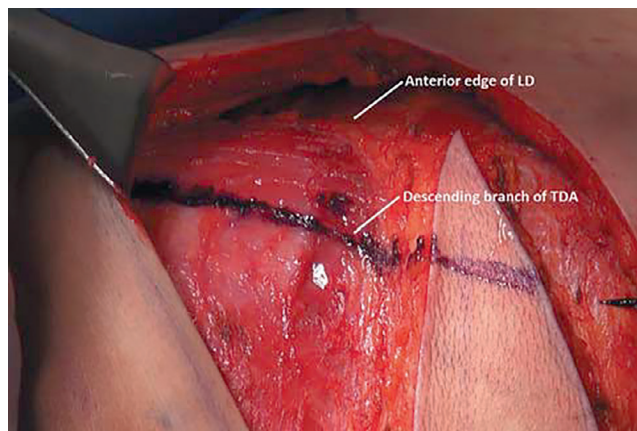
Surgical Techniques

Preoperative Markings

In the preoperative waiting area, the patient is marked in a standing position. The sternal notch, anterior midline, clavicle, inframammary fold, breast footprint, inferior border of the scapula, posterior midline, and posterior superior iliac spine are marked. The LD margins are marked after identifying the anterior edge of the muscle, and then re-creating the expected origin and insertions based on the anatomic landmarks previously discussed (see Cases 8.1 & 8.2). In a standard LD flap, the skin paddle is designed



• **Fig. 8.6** Preoperative flap marking of muscle-sparing latissimus dorsi (MS-LD). The skin paddle is designed over the axis of the descending branch of the thoracodorsal artery, oriented transversely or with a slightly oblique orientation. TDA, thoracodorsal artery. (Reproduced from Saint-Cyr M, et al. A simple approach to harvest of the pedicled descending branch muscle-sparing latissimus dorsi flap. *J Plast Reconstr Aesthet Surg.* 2015;68:e179-e181, Figure 1.)



• **Fig. 8.7** Identification and marking of the descending branch of the thoracodorsal artery (TDA). The course of the descending branch is marked on the superficial surface using a handheld Doppler ultrasound superior to the skin paddle. (Reproduced from Saint-Cyr M, et al. A simple approach to harvest of the pedicled descending branch muscle-sparing latissimus dorsi flap. *J Plast Reconstr Aesthet Surg.* 2015;68:e179-e181, Figure 2.)

horizontally at the level of the bra strap, with the pinch test to determine the dimensions of the skin paddle. In the ELD, the patient is asked to flex their trunk in the ipsilateral direction to accentuate the fat compartments and the thoracolumbar, lumbar fat compartments are grasped simultaneously in a “double-bubble” pinch test, and the skin paddle is marked within the crease between the two fat compartments (see Fig. 8.1). To optimize capture of the perforating vessels, a handheld Doppler probe can be used to identify and mark the thoracodorsal artery and its perforators. The skin paddle can then be modified to incorporate the maximum number of perforators (Figs. 8.6 & 8.7).

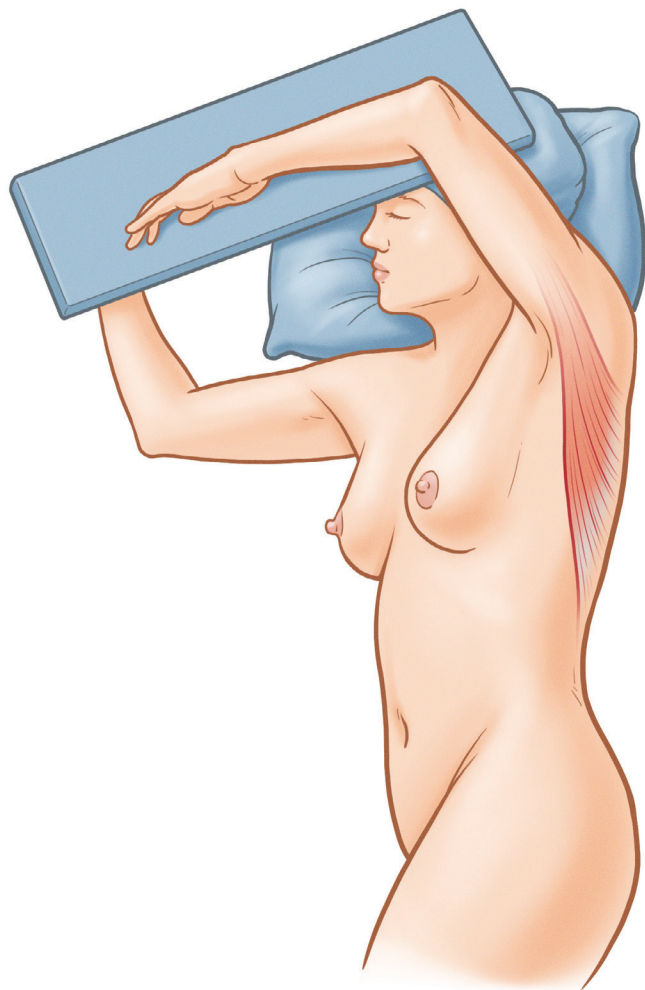
In patients undergoing fat grafting, the preferred donor sites are marked preoperatively, which commonly include the abdomen, flanks, and thighs. However, patient preference dictates the available donor sites.

Surgical Exposure

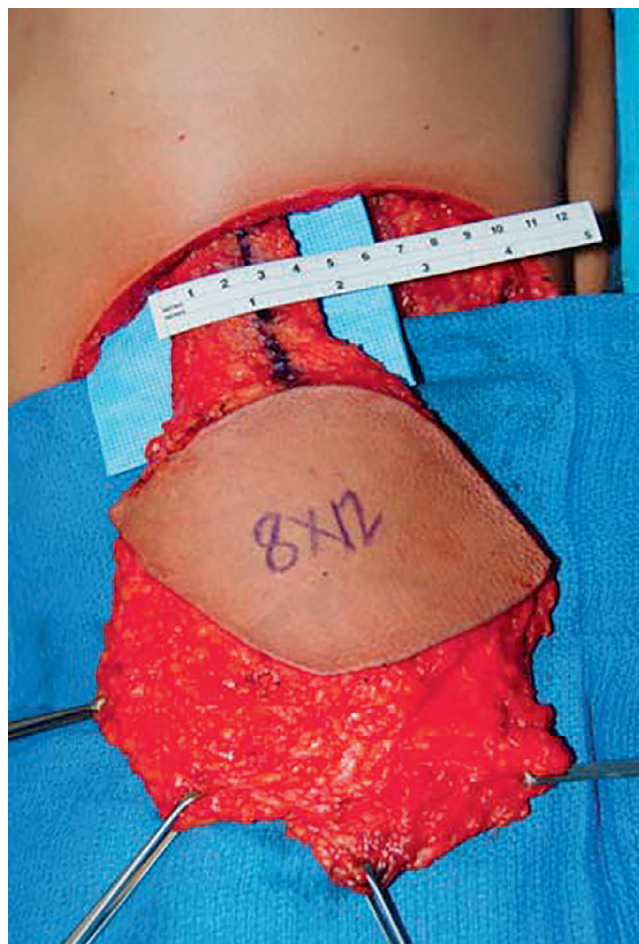
In a unilateral, delayed LD breast reconstruction, the patient is positioned into a contralateral lateral decubitus position. An axillary roll is placed underneath the axilla and the contralateral arm is secured on a well-padded arm board in approximately 90 degrees of shoulder flexion. Similarly, a well-cushioned Mayo stand is set to the height of the ipsilateral arm, and the arm is secured at approximately 90 degrees of shoulder flexion (Fig. 8.8).

The superior margin of the skin paddle marking is first incised, and then dissected perpendicularly to the skin incision to the deep muscle fascia, in order to not incorporate

the superficial fascial layer in our flap and to provide additional strength for the donor-site closure to decrease the risk of wound dehiscence. Dissection proceeds superiorly to the marked thoracolumbar fat compartment (or angle of scapula), with care taken to leave a thin layer of subcutaneous tissue over the marked axis of the descending branch of the thoracodorsal artery. Following the principles of flap vascularity and inter-perforator flow, we endeavor to maximize the number of perforators incorporated within the flap. As previously mentioned, parascapular fat is left unviolated, in an attempt to avoid a visible hollowed appearance. The teres major is identified along the superior aspect of the latissimus dorsi, and the trapezius is identified superficial and medial to the latissimus dorsi. Identification of these muscles is critical in avoiding their inadvertent incorporation during flap elevation. The height of the skin paddle that can be safely harvested is by advancing the elevated superior tissues inferiorly using penetrating towel clamps and marking the areas of overlap. Adjustments to the skin paddle are made at this time (Figs. 8.9 & 8.10).



• **Fig. 8.8** Intraoperative patient positioning. The patient should be positioned with cushioning at all points of potential pressure. (Adapted from Gart M, et al. Latissimus dorsi flap breast reconstruction. In: Nahabedian MY, Neligan PC, eds. Plastic Surgery. 4th ed. Vol 5. © 2018, Elsevier Inc.)

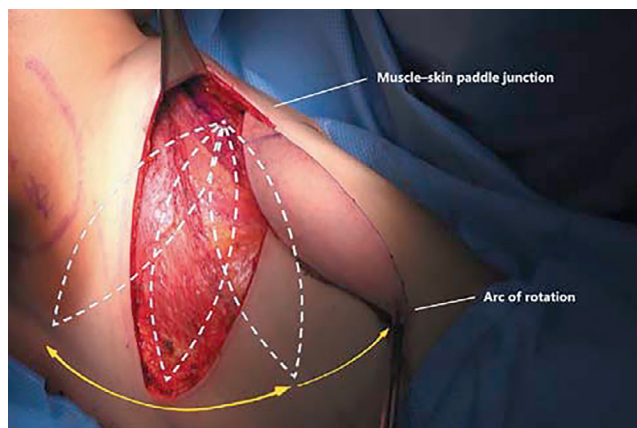


• **Fig. 8.9** An extended descending branch muscle-sparing latissimus dorsi flap harvested with a cuff of adipose tissue for additional soft tissue volume and coverage. (Reproduced from Saint-Cyr M, et al. The pedicled descending branch muscle-sparing latissimus dorsi flap for breast reconstruction. *Plast Reconstr Surg.* 2009;123:13, Figure 5.)



• **Fig. 8.10** Intraoperative photograph demonstrating harvest of the extended latissimus dorsi (E-LD) flap. Note that the lumbothoracic, lumbar, and a portion of the suprailiac fat compartments are harvested with the skin paddle to yield maximal volume. (Reproduced from Saint-Cyr M, et al. The low transverse extended latissimus dorsi flap based on fat compartments of the back for breast reconstruction: anatomical study and clinical results. *Plast Reconstr Surg.* 2011;128:382e, Figure 3.)

The inferior margin of the skin paddle marking is incised to the level of the subcutaneous tissue and dissected to the level of the deep muscle fascia. The inferior aspect of the muscle is exposed by dissecting in the subfascial (superficial fascial system) plane to approximately 3–4 cm superior to the iliac crest to maximize harvest of the lumbar fat compartment. After exposing the entire latissimus dorsi muscle, it is dissected free from its origins (spinous process of lumbar spine, inferior ribs, iliac crest, thoracolumbar fascia, and inferior angle of the scapula). The pace of surgical dissection is adjusted while operating towards the axilla, with extreme precaution taken to avoid injury to the neurovascular bundle, and the axillary lymphatic system. Injury to the lymphatic system can have significant consequences, particularly ipsilateral upper extremity lymphedema. We routinely preserve the insertion of the muscle onto the humerus, and the innervation of the muscle from the thoracodorsal nerve. A subcutaneous tunnel is created towards the mastectomy pocket and the flap is transposed into the mastectomy defect, after careful orientation of the flap. The subcutaneous tunnel is assured to be free of any restrictive

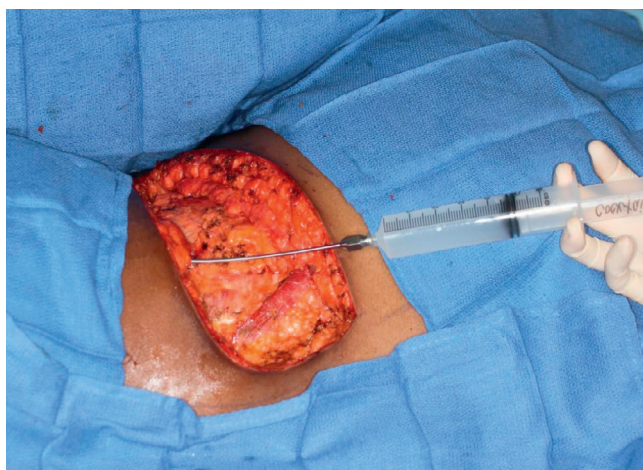


• **Fig. 8.11** The axis of rotation at the flap–muscle junction. The skin paddle can be rotated up to 90 degrees clockwise or counterclockwise, which increases its area of reach. (Reproduced from Saint-Cyr M, et al. A simple approach to harvest of the pedicled descending branch muscle-sparing latissimus dorsi flap. *J Plast Reconstr Aesthet Surg.* 2015;68:e179–e181, Figure 4.)

scarring and bands, particularly in previously irradiated breasts. Careful release and excision of the mastectomy scar tissue and subcutaneous bands can often recreate the original mastectomy defect, thus converting a delayed reconstruction defect into an immediate one.

In a two-team approach, the mastectomy flaps can be elevated at the time of LD flap harvest. The breast pocket is designed according to the following dimensions: 2 cm lateral from the anterior midline, superior to the level of the clavicle, and inferior to the inframammary fold. A subcutaneous tunnel is then dissected towards the axilla connecting with the subcutaneous tunnel created from the donor site. An orientation stitch is placed on the inferior, medial aspect of the LD skin paddle in every case to ensure safe orientation of the flap. All tethering fascial and scar bands are released within the subcutaneous tunnel and the flap is transposed into the defect by rotating the distal aspect of the flap to become the medial aspect of the breast tissue. Rotational direction is determined by the laterality of the flap, as left LD flaps are rotated in a clockwise manner, and right LD flaps are rotated in a counterclockwise direction (Fig. 8.11). The pedicle is routinely examined during the procedure to be free of twisting, kinking or tethering.

The LD skin paddle is secured to the mastectomy skin flap with surgical staples, and iodine-impregnated incision drape (3M Ioban 2, St. Paul, MN) is applied to the anterior chest to maintain sterility. Two 15 French Jackson–Pratt surgical drains (CardinalHealth, Dublin, OH) are placed in the donor bed, one underneath the superior flap and the other underneath the inferior flap. The surgical site (upper and lower flanks and surrounding musculature) is infiltrated with 0.25% bupivacaine (Fig. 8.12). Empty space is obliterated with the use of progressive tension sutures (3-0 Stratafix barbed suture (Ethicon US, LLC, Somerville, NJ) or 2-0 Vicryl (polyglactin, Ethicon US)), which also serve to decrease the tension of donor-site closure. Quilting sutures



• **Fig. 8.12** The donor site is infiltrated with a local anesthetic cocktail using a blunt tip cannula to provide postoperative pain control. (Adapted from Gart M, et al. Latissimus dorsi flap breast reconstruction. In: Nahabedian MY, Neligan PC, eds. Plastic Surgery. 4th ed. Vol 5. © 2018, Elsevier Inc.)

or progressive tension sutures are not placed in the proximity of the pedicle or along the anterior border of the LD muscle, in order to avoid pedicle compression and venous congestion. (Videos 8.1 & 8.2 demonstrate progressive tension sutures and quilting sutures technique. Video 8.2 demonstrates the obliteration of empty space after performing quilting sutures at the donor site.) The donor site is closed in multiple layers, with 3-point superficial fascial tacking sutures to set the location of the scar (2-0 PDS II (polydioxanone, Ethicon US, LLC, Somerville, NJ)), deep dermal closure with 2-0 Vicryl and 3-0 Monocryl (poligle-caprone, Ethicon US, LLC), and with a running intradermal closure using 4-0 Stratafix barbed suture, 3-0 Monocryl or a subcuticular skin closure using either a 3-0 or 4-0 Monocryl. Dermabond Prineo (Ethicon US, LLC) surgical glue is applied to the incision to create a water-resistant seal, and the Jackson–Pratt surgical bulbs are attached to the surgical drains.

The patient is then placed in a supine position, and all exposed areas undergo repeat surgical sterilization and draping. In patients undergoing fat grafting, the donor sites are also similarly prepared. Depending on patient positioning, fat harvest can be performed during flap harvest or prior to flap inset.

Fat Grafting

Donor sites for fat harvest are infiltrated with a tumescent solution (1 L of lactated Ringer's or a 0.9% normal saline solution, 40–50 mL of 1% lidocaine, and 1 ampule of epinephrine). Lipo-aspiration is performed using a 3.7–4-mm cannula and the fat can be processed with centrifugation (3 min) using the established Coleman technique, or another fat harvesting system of choice (e.g. Revolve, Life-Cell Co, Bridgewater, NJ). The harvested fat is then

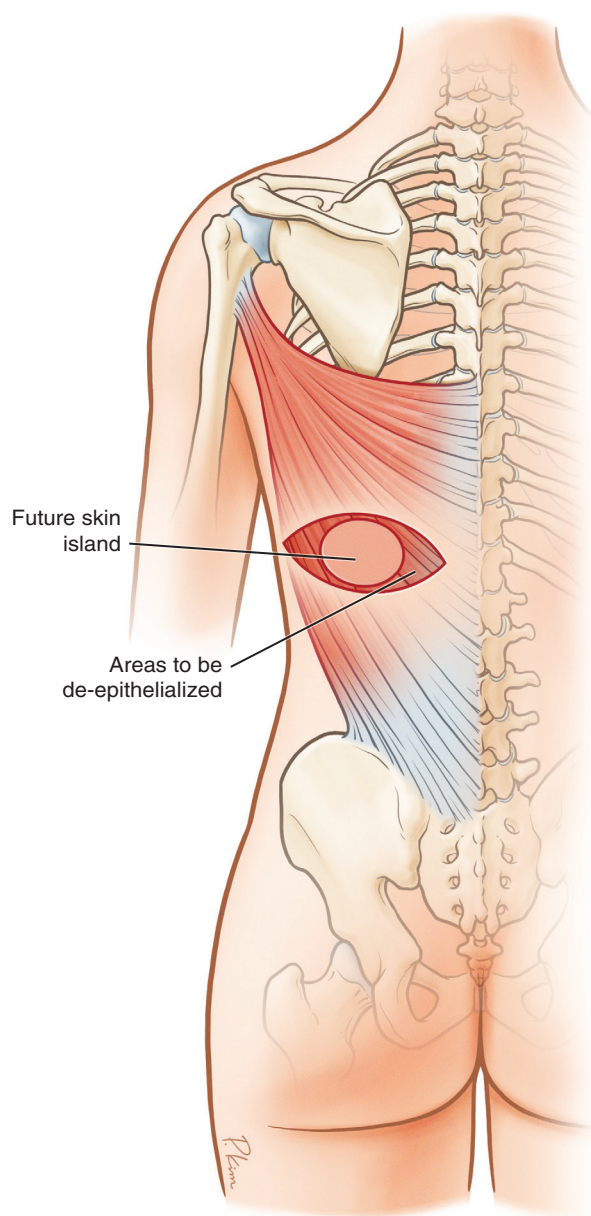
transferred into 10-mL syringes for injection. Immediate fat grafting in LD-based reconstruction allows for grafting in multiple recipient beds, which include:⁶

1. Latissimus dorsi skin paddle
2. Latissimus dorsi muscle, deep to the skin paddle
3. Pectoralis major muscle, distal and posterior to the skin paddle
4. Anterior serratus muscle
5. Mastectomy skin flap (only in a delayed reconstruction).

The areas of fat grafting are limited by the oncological status of the patient. In delayed breast reconstruction, all recipient sites can undergo fat grafting. In immediate breast reconstruction for prophylactic mastectomy, fat grafting is avoided in the mastectomy skin flap to minimize the risk of skin flap necrosis or recipient site complications. In immediate breast reconstruction for breast cancer, fat is grafted only into the latissimus dorsi skin paddle and latissimus dorsi muscle caudal to the skin paddle.³ (Video 8.3 demonstrates intraoperative fat grafting of the LD flap). Fat is injected into the recipient beds using a mini Coleman or Khouri cannula. It is imperative to adhere to known fat grafting principles, and only inject small aliquots, in a retrograde fashion in multiple layers to evenly distribute the fat, optimize the successful “take,” and to decrease the risk for formation of fat necrosis or lipid cysts.

The LD flap is oriented at the recipient site to provide the best projection and final shape. The caudal muscular portion of the LD is often positioned medially and superiorly to provide a smooth transition from the skin paddle and for greater fullness in the cleavage line and upper pole. The medial end of the skin paddle can also be gently folded under itself to provide extra projection along the inferior pole when the skin paddle is inset vertically or along the medial cleavage line when inset horizontally. If the reconstruction is planned to be augmented with implants in the immediate or delayed setting, a subpectoral plane is elevated, and the implant or tissue expander is placed into the subpectoral pocket. The LD flap is then used to provide additional anterior and lower pole soft tissue coverage.

The LD flap is anchored medially with 2-0 Vicryl sutures to the pectoralis major muscle fascia and Scarpa's fascia to prevent lateral migration. The LD skin paddle can be modified to meet the specific needs at the site of the mastectomy. In certain cases, the skin paddle can be trimmed to have a circular shape for future nipple–areola complex reconstruction (Fig. 8.13). During flap inset, the inframammary crease, lateral mammary fold, and breast footprints can be redefined with tacking sutures and capsulorrhaphy sutures to recreate an aesthetic breast, rather than just a mound of flap tissue. Surgical drains are placed into the mastectomy defect prior to final closure. The flap is inset with interrupted deep dermal sutures using 3-0 Monocryl, and a running 3-0 intradermal Stratafix. Surgical glue (Dermabond Advanced Topical Skin Adhesive, Ethicon US, LLC, Somerville, NJ) is applied to the incision to create a water-proof barrier, and the patient is placed in a well-padded surgical bra for additional support.



• **Fig. 8.13** The skin paddle can be adjusted to meet the requirements of the donor-site defect. The excess skin can be de-epithelialized off of the paddle to leave a circular skin paddle matching the ipsilateral native nipple–areola complex. (Adapted from Gart M, et al. Latissimus dorsi flap breast reconstruction. In: Nahabedian MY, Neligan PC, eds. Plastic Surgery. 4th ed. Vol 5. © 2018, Elsevier Inc.)

Bilateral Breast Reconstruction

In bilateral breast reconstruction with LD flaps, similar principles of flap design, harvest techniques, and transposition apply. Patients can be placed in a prone position for bilateral simultaneous LD flap harvest, or in a lateral decubitus positioning for individual flap harvest. Body contouring in this region, with selective suction lipectomy, can help recreate an “hourglass” figure in certain patients. In very high BMI patients, flap harvest may need to be done in the lateral decubitus position in order to have access to the breast pocket for temporary inset of their large flaps.

Case Examples

CASE 8.1

A high-BMI patient planned to undergo bilateral simple mastectomy was a poor candidate for abdominal-based free flap breast reconstruction. She was noted to have adequate volume of the latissimus dorsi donor site. The skin paddle design is obliquely oriented to maximize volume harvest and care is taken to be below the inferior aspect of the scapula and superior to the iliac crest. The skin paddle measured 31×17 cm. Short-term postoperative results demonstrate reconstruction of bilateral breasts with large volume latissimus dorsi flaps.

CASE 8.2

A middle-aged woman with left breast cancer was planned to undergo bilateral simple mastectomy and did not desire an abdominal-based breast reconstruction. She underwent implant-based reconstruction on the right, and had left breast reconstruction with a latissimus dorsi flap after completion of radiation therapy. She underwent a revision procedure with fat grafting of both breasts for superior pole volume, and to address contour deformities. The donor-site scar is in an acceptable position, easily concealable underneath a bra strap.

CASE 8.3

A high-BMI patient who had undergone bilateral breast mastectomy presented in a delayed fashion for breast reconstruction. She was a poor candidate for an abdominal-based breast reconstruction and was noted to have adequate volume of the latissimus dorsi donor site. The creases of the different fat compartments can be easily seen in this patient. Flap harvest was limited to the thoracolumbar and lumbar fat compartments to avoid distal flap fat necrosis and to prevent contour deformities of the scapular region. Short-term postoperative results demonstrate the creation of the breast mound and the donor-site scar is obliquely oriented due to the design of a larger flap.

CASE 8.4

A woman with right breast cancer presented for reconstruction after a right-sided lumpectomy and radiation therapy. She did not desire abdominal-based free flap reconstruction and elected to proceed with a right latissimus dorsi flap reconstruction. The operative surgical markings (see Fig. 8.6) include the inferior angle of the scapula (purple S), the anterior edge of the latissimus dorsi muscle and the expected location of the pedicle (black ink). The skin paddle is marked horizontally at the level of the bra strap, with a purple horizontal line marked at the level of the planned donor site scar. In the short-term postoperative period, she has achieved adequate volume supplementation of the inferior pole of the right breast and the donor site is well healed and is positioned at the level of the bra strap.

Postoperative Care and Expected Outcomes

Postoperatively, the patient is placed in a surgical bra to provide support of the reconstructed breast and for comfort. For women who undergo simultaneous fat grafting, donor sites are compressed with an abdominal binder (abdomen or flank), and lower extremity compression garments (thighs). The patient is admitted for inpatient monitoring, and initiated on a standard protocol to optimize pain control and achieve early return to activities and postoperative goals. A pillow is positioned between the patient's arm and trunk on the ipsilateral side, and the patient is instructed to sleep in a supine or slightly inclined position, to decrease the risk for pedicle compression. Patients are encouraged to ambulate (with assistance as needed) on the first postoperative day in the hallways, and receive additional physical and occupational therapy evaluation. Most women are discharged within the first two postoperative days. Drains are removed when the daily drain output is less than 30 mL per day for two consecutive days, which is usually within the first two weeks.⁷ Physical activity is limited during the first 4 weeks, with restriction on shoulder abduction greater than 70–90 degrees, and avoidance of overhead activities. The patient is allowed to slowly incorporate activities requiring significant shoulder motion and strength after this time.

Management of Complications

Seroma formation is the most common donor-site complication, with increased risk when using an ELD harvest, and in the obese population.² Less frequent donor-site complications include dorsal skin flap necrosis, wound breakdown, shoulder weakness or restricted range of motion, winging of the scapula, and dorsal hernia.⁴ Seroma rates can be decreased with donor-site closure using quilting sutures and fibrin glue. Postoperatively, most seromas are successfully managed with repeat aspiration and application of compression dressings. Recalcitrant cases of seroma can be treated with sclerotherapy (doxycycline), injection of triamcinolone, capsulectomy, or by placement of a drain. Wound separation and dehiscence (fascial separation) can be managed non-operatively with wound care and allowed to heal secondarily. Superficial skin infection is treated with oral antibiotics, while patients with deep spaces are admitted for intravenous antibiotics, and for operative wound washout. Functional outcomes of the shoulder vary significantly between the patients. Most often the concern is with motor endurance of the shoulder and with overhead activities (ladder climbing, push-up from a chair, and swimming). Although infrequent, patients with persistent weakness or with limited range of motion can benefit from physical therapy.

Flap-related complications are rare, and are usually due to injury to the vascular pedicle. If there appears to be evidence of venous congestion (purple flap, immediate

capillary refill) or arterial compromise (pallor, poor capillary refill) to the flap immediately after transposition, the pedicle is examined for evidence to identify the location of vascular compromise visually or with the aid of a handheld Doppler. Any evidence of flap vascular compromise after inset requires re-exploration of the surgical site to ensure that the pedicle is not under excess tension from the flap, or to evacuate a potential hematoma which might externally compress the pedicle. We typically use an anchoring suture from the LD muscle to the pectoralis muscle fascia to avoid any inadvertent tension on the pedicle.

Steatonecrosis of the distal portions of the flap can present as palpable, firm masses which can be anxiety-provoking in patients with a history of breast cancer. Fat necrosis is easily distinguishable from a malignant mass of the breast with radiographic imaging, and additional testing is not frequently required. The necrotic tissue can be surgically excised to alleviate any patient concerns or be softened with suction lipectomy. Contour deformities after excision or liposuction can be improved upon with fat grafting.

Implant-related complications with rupture, exposure, malposition, asymmetry and capsular contracture might require revision procedures. Implant placement in the subpectoral plane, with lower pole coverage using the LD, helps decrease implant-related complications.

Secondary Procedures

Secondary revision procedures to optimize the size and contour of the breasts are routinely performed. In women desiring larger breasts, the volume can be augmented with the placement of an implant, with additional fat grafting of the LD flap and mastectomy skin, or by advancement of a thoracoabdominal advancement flap (TAAF). For women undergoing implant placement or exchange of their tissue expander for a permanent implant, the skin is incised through the mastectomy incision. The pectoralis muscle or the latissimus dorsi is parallel to the muscle fibers, and implant capsule modifications are made as needed.

Women desiring smaller breasts can undergo excision of excess flap tissue, suction lipectomy or a mastopexy. Minor contour deformities are managed with fat grafting and liposuction. Nipple–areola reconstruction is performed only after the breast mound has undergone final revision procedures to ensure symmetry and optimal location of nipple–areola complex. The skin of the LD can be de-epithelialized and the mastectomy skin flaps can be advanced to create a circular skin paddle to approximate the size and shape of the native areola. The nipple–areola complex can also be recreated with 3-D tattooing.

Conclusions

The LD flap is an excellent option for autologous breast reconstruction in women who are not ideal candidates for prolonged surgical procedures, or for women who are poor candidates for abdominal-based pedicled or free flap

reconstruction. The flap can be modified to meet particular needs and can be augmented in the immediate or delayed setting with an implant or with fat grafting. Care must be taken in securing the pedicle and the flap after transfer, to prevent undue tension on the pedicle. The ELD is an excellent option for reconstruction of medium to larger-sized breasts, but comes with an increased risk of flap-related complications. The risk of seroma formation can be decreased by utilizing progressive tension sutures, quilting sutures and with the application of a fibrin sealant. The primary disadvantages include the need for intraoperative patient position change, and the risk for deficits in shoulder function. The patient should be counselled regarding rare postoperative incidents of shoulder abduction weakness on the operated side and the potential need for physical therapy.

PEARLS FOR SUCCESS

- Complete autologous reconstruction of larger breasts can be performed with the ELD flap with immediate or delayed fat grafting.
- If additional fat is harvested with the flap, ELD harvest should be limited to the thoracolumbar and lumbar fat compartments, to obtain an “hourglass” contour and to avoid deformities of the upper back or fat necrosis within the flap.
- Seroma formation is minimized with the use of quilting suture, progressive tension sutures, and fibrin glue during donor-site closure.
- Breast mound landmarks should be recreated using tacking sutures and by performing selective capsulorrhaphy of the inframammary and lateral mammary folds.
- The skin paddle can be folded under itself, providing additional projection of the medial breast and for creation of cleavage. Vertical or vertical oblique inset with projection sutures can provide excellent cosmesis and medial fullness.
- The flap should be secured to the pectoralis fascia to prevent flap descent or lateral migration, which can compress the pedicle and compromise the flap.
- Patients should be counselled preoperatively regarding the risk of shoulder weakness, and prompt referral to physical therapy is required in women who demonstrate prolonged notable limitations.

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9

Immediate Implant Breast Reconstruction – One-Stage

JORDAN D. FREY AND MIHYE CHOI

Introduction

Implant-based, or alloplastic, breast reconstruction is the most commonly performed method of breast reconstruction.¹ Within implant-based reconstruction, myriad techniques and reconstructive strategies are at the surgeon's disposal to provide each individual patient with a successful breast reconstruction. Traditional immediate alloplastic breast reconstruction involves a two-stage approach in which a temporary tissue expander is placed and variably expanded in the outpatient setting, after which it is exchanged for a permanent implant in a second operative procedure. Alternatively, a permanent implant may be placed immediately after mastectomy in a one-stage fashion. This technique obviates the need for tissue expansion and subsequent device exchange. When combined with nipple-sparing mastectomy, the need for nipple reconstruction is also obviated, offering patients the potential for a complete breast reconstruction in a single operative setting.²

Compared to two-stage tissue expander-based breast reconstruction, placement of an immediate, permanent device requires greater technical precision in implant pocket creation as well as device selection and placement. While the majority of tissue expander-based reconstructions may be performed with a total submuscular technique, immediate placement of a permanent implant will often require the use of a scaffold for inferolateral support and coverage given the greater initial device volume. Moreover, permanent implants do not allow for adjustment of initial device volume as with tissue expanders. Therefore, a greater initial tissue stress is placed on the overlying breast skin envelope by the underlying implant. Proper patient selection and intraoperative assessment is thus critical to minimize risk of adverse outcomes.

Implant-based breast reconstruction continues to evolve and progress towards complete breast reconstruction in a single stage. Two-stage reconstruction using tissue expansion remains the traditional approach, demonstrating safe

and aesthetic results. However, with careful preoperative evaluation and patient selection as well as meticulous operative technique, immediate placement of a permanent device offers the potential for one-stage implant-based breast reconstruction with excellent outcomes.

Indications and Contraindications

General indications for one-stage immediate implant breast reconstruction include two groups of patients in our practice. The first group is patients who qualify for nipple-sparing mastectomy (total skin-sparing) with smaller, minimally ptotic breasts who desire similar sized breasts postoperatively. The second group is patients who are undergoing skin-sparing mastectomy with larger breasts who desire smaller breasts postoperatively.

Patients desiring a larger breast size compared to their preoperative size will inherently require tissue expansion and a two-stage reconstruction. Moreover, elderly patients or those with significant co-morbidities may be preferentially offered single-stage reconstruction to avoid a second surgery and general anesthetic.

Constricted as well as large or ptotic breasts represent relative contraindications for immediate implant-based reconstruction. In these patients, it is often difficult to match the overlying skin envelope to the underlying implant pocket comprised of the pectoralis muscle and, most often, soft tissue scaffold support, such as acellular dermal matrix. This discrepancy will compromise the final aesthetic result of the reconstruction. In patients with larger or ptotic breasts, mastectomy flaps with greater distance to edges and surface area will have increased risk for inadequate perfusion, elevating risk of wound healing complications. Patients with nipple to sternal notch distances greater than 25 cm, severe grade II or grade III breast ptosis must thus be approached cautiously. Further, direct-to-implant reconstruction with devices greater than 400 mL in volume has been associated with increased complications, providing further evidence

that patients with and desiring larger breasts represent sub-optimal candidates for one-stage implant reconstruction.²

Immediate reconstruction using a skin reduction pattern mastectomy incision or delayed mastectomy and reconstruction after staged reduction mammoplasty are strategies to mitigate these issues in patients with larger, ptotic breasts, but carry a higher scar burden with inherent risk of wound healing issues. Reconstruction using a Wise pattern incision and immediate, permanent implant placement may also be combined with an inferior dermal flap for implant coverage. However, wound healing complications remain elevated and were observed in 25% of cases in one series.³

Lastly, the volume of a permanent implant cannot be manipulated as with a tissue expander. This places greater immediate stress on the breast skin envelope; therefore any factor that necessitates skin envelope reduction will inherently create greater tissue strain. Therefore, non-nipple-sparing mastectomy techniques and breast tumors close to the skin requiring skin excision may be considered relative contraindications to immediate implant-based breast reconstruction. Severe nipple–areola complex malposition within those undergoing nipple-sparing mastectomy as well as chest wall asymmetry in all patients represent additional contraindications for one-stage implant-based breast reconstruction (Table 9.1).

Preoperative Evaluation

Patients presenting in consultation for immediate implant-based breast reconstruction should undergo a comprehensive examination to assess their candidacy for a one-stage reconstruction. Such examination should begin with an evaluation of the patient's breasts. Four aspects of the breast exam are essential in evaluation.

First, the breast footprint and chest wall symmetry should be examined carefully. A constricted breast base or asymmetrical chest wall are relative contraindications for

one-stage reconstruction. Any asymmetry should be pointed out and discussed with the patient.

Secondly, the breast envelope including skin quality, elasticity, and ptosis are assessed. Standard breast measurements, including nipple to sternal notch distance, nipple to inframammary fold distance, and base width should be measured. In this regard, the most appropriate candidates for one-stage implant-based reconstruction are those with good skin quality and elasticity, minimal skin laxity, and grade I or mild grade II ptosis with a nipple to sternal notch distance of less than 25 cm. In these patients, mastectomy skin flaps are optimally perfused while the underlying implant pocket can be matched to the overlying breast skin envelope to maximize outcomes. As discussed earlier, patients with nipple to sternal notch distances greater than 25 cm, severe grade II or grade III breast ptosis must thus be approached cautiously as they are at greater risk of reconstructive complications as well as suboptimal aesthetic results.

Thirdly, in patients undergoing nipple-sparing mastectomy, nipple–areola complex position must be carefully assessed. Optimal position is defined as that centered at the most projecting point of the breast combined with minimal or no ptosis. Patients with no or mild nipple–areola complex ptosis are optimal candidates for one-stage implant-based reconstruction whereas moderate ptosis must be approached with caution. Patients with severe nipple–areola complex malposition are better served with a two-stage reconstruction to allow for staged adjustment of nipple position. Nipple position asymmetry should be assessed and discussed. Inter-nipple distance relative to the nipple to anterior axillary line should be assessed. Patients with natural nipple divergence are at a higher risk for lateral nipple malposition postoperatively. In appropriately selected patients, strategies for optimizing nipple–areola complex position at the time of initial reconstruction includes suturing it to the underlying muscle or scaffold as well as setting the proper position after the incisions are

**TABLE
9.1**

General Indications and Contraindications for One-Stage Immediate Implant Breast Reconstruction

Indications	Absolute Contraindications
Small-breasted patients Nipple-sparing mastectomy Minimal ptosis (grade I to mild grade II) Nipple to sternal notch distance <25 cm Similar postoperative breast size desired	Patient desire for larger postoperative breast size Severe macromastia Severe chest wall asymmetry Severely constricted base (tuberous breast deformity) Severe preoperative nipple–areola complex malposition (with nipple-sparing mastectomy)
Larger-breasted patients Skin-sparing mastectomy Desire smaller postoperative breast size	Severe grade II/III ptosis desiring nipple-sparing mastectomy
Relative Indications	Relative Contraindications
Elderly or co-morbid patients	Large, ptotic breasts (grade II/III ptosis) Nipple to sternal notch distance >25 cm Predicted permanent implant size >400 mL Non-nipple-sparing mastectomy Breast tumor close to skin

closed and immediately placing drains on closed suction.⁴ If nipple–areola complex malposition persists or presents postoperatively, various strategies including crescentic excision and mastopexy-type procedures may be successfully employed.⁴

Lastly, breast volume should be assessed and discussed in relation to the desired size. If the patient desires her breasts to be at least one cup size larger, one-stage immediate implant reconstruction should not be offered. In this case, a two-stage technique is preferred as, with a nipple-sparing technique, only a slightly fuller upper breast pole can realistically be achieved with one-stage immediate implant reconstruction. If the patient's breasts are very large or ptotic and prophylactic mastectomy is planned, we prefer to perform reduction/mastopexy first followed by nipple-sparing mastectomy and one-stage reconstruction in a second operative procedure. In patients with large, ptotic breasts undergoing therapeutic mastectomy in which a staged reduction/secondary reconstruction is precluded, a one-stage immediate implant reconstruction may be performed using a Wise pattern skin incision combined with an inferior pedicle adipodermal flap for additional implant coverage.

With regards to implant selection, there are many important factors to consider. Perhaps the most important measurement in making this decision is base width. Once the base width is measured and selected, implant size and projection are selected based on mastectomy weight and patient preference, balancing implant dimensions with the requisite of minimizing final tension on mastectomy flaps. Implant type must then be determined in conjunction with the patient. Smooth, round implants offer advantages such as a natural feel with less risk of complications, compared to the infectious risk seen with their textured counterparts.⁵ Textured, anatomic implants may offer a superiorly visualized breast aesthetic, especially in unilateral reconstructions and patients with a long or tall breast footprint.⁵ However, patients must be advised of potential risks of implant rotation and breast implant–associated anaplastic large cell lymphoma with use of textured implants.⁶ In our practice, smooth, round implants are utilized in approximately 90% of immediate one-stage implant reconstructions.

Consideration should be given to the possibility of revision. This should be discussed prior to the surgery. Once this reconstructive plan is established, patients may conclude that no further surgery will ever be needed. It is important to emphasize that one-stage implant-based breast reconstruction entails a one-stage breast mound restoration. However, refinement or fine-tuning of the initial result may require a touch-up surgery. This may include fat grafting, implant exchange, scar revision, nipple–areola complex position adjustment, or nipple reconstruction, among other procedures.

Surgical Techniques

Patients are marked in the upright procedure. The midline is marked using the sternal notch and xiphoid as landmarks.

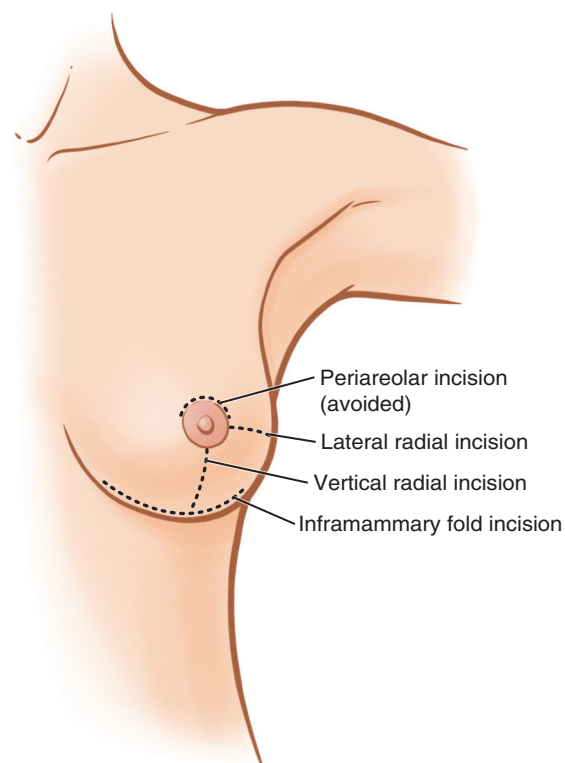
The inframammary fold is marked along with the upper breast border. Mastectomy incisions are designed in conjunction with the oncologic surgeon. In non-nipple-sparing mastectomy techniques, an elliptical incision encompassing the nipple–areola complex is typically chosen. Incision options in nipple-sparing mastectomy include lateral radial and vertical radial as well as inframammary fold approaches. Radial incisions are marked from the edge of the nipple–areola complex. For instance, for a vertical radial incision, the marking extends from the 6 o'clock border of the nipple–areola complex to the midpoint of the inframammary fold whereas in a lateral radial incision, the marking extends from the 3 o'clock or 9 o'clock position of the nipple–areola complex to the midpoint of the lateral breast footprint. Advantages of radial incisions include excellent surgical access to the entirety of the breast for mastectomy; however, the scars are visible on frontal view postoperatively. Inframammary fold incisions may be marked along the entire inframammary fold or only its lateral portion, extending from the midpoint of the breast to the lateral aspect. Advantages of inframammary fold incisions include a well-hidden final scar, but access for mastectomy is more limited, particularly to the superior extent of the breast.

In our practice, these three incision types are most commonly utilized for nipple-sparing mastectomy: inframammary fold (58.3%), lateral radial (18.6%) and vertical radial (13.3%). Inframammary fold incisions are employed for patients with small or moderate-sized breasts while radial incisions are utilized for patients with larger breasts to provide greater surgical access for mastectomy. Radial incisions are also favored in microsurgical reconstruction to allow for better access to the internal mammary recipient vessels. In general, periareolar incisions are avoided, even as extensions of radial incisions, to limit the ischemic insult to the nipple–areola complex (Fig. 9.1). Although less common, vertical radial and inframammary fold incisions may be combined in nipple-sparing mastectomy, especially in patients having undergone a previous breast reduction, to increase surgical access and visualization.

If a skin reduction pattern is chosen in conjunction with skin-sparing mastectomy, markings are similar to those for a Wise pattern breast reduction. Divergent vertical limbs are marked with an apex above the nipple–areola complex and extend along the lateral borders of the nipple–areola complex for approximately 6 cm. The angle of divergence is determined by displacing the breast medially and laterally, aligning the medial and lateral limbs with the breast meridian. Horizontal limbs are then drawn connecting the vertical limbs with the previously created inframammary fold marking. Another horizontal line is then drawn connecting the inferior points of the vertical limbs. This creates a triangle through which the mastectomy will be performed. Once the mastectomy is complete, the inferior pedicle adipodermal flap (hatched lines in Fig. 9.2A) is de-epithelialized and the horizontal limbs are incised. The remaining procedure is identical to that discussed below with the inferior

pedicle adipodermal flap being used for additional inferior device coverage (Fig. 9.2).

Upon entering the operating room, the patient is placed on the operating table supine with the arms abducted at 90 degrees and secured. The breast is then infiltrated with a

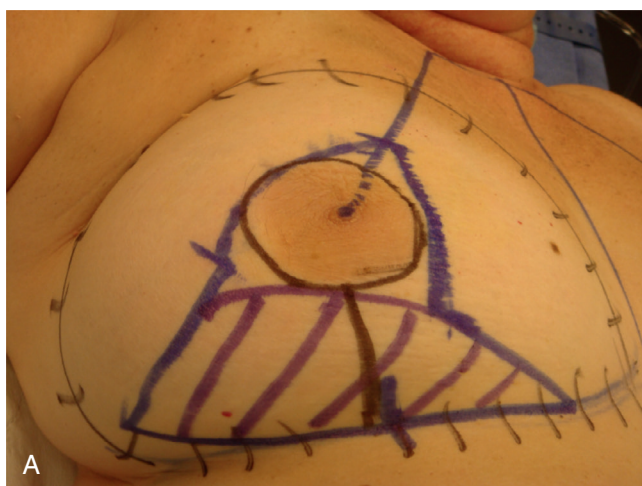


• **Fig. 9.1** Diagram depicting various mastectomy incisions available to be utilized for nipple-sparing mastectomy.

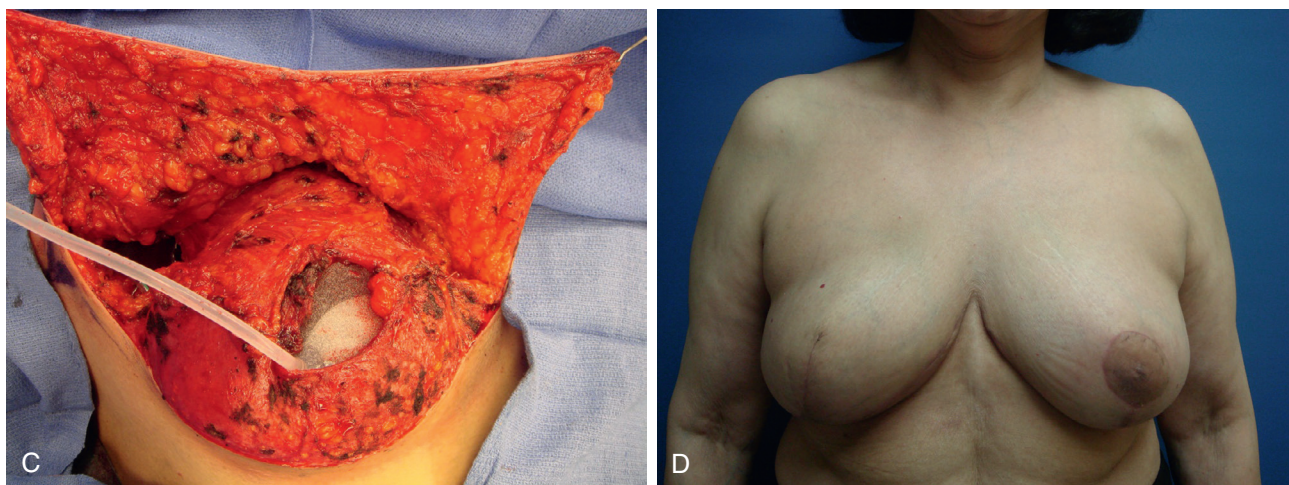
dilute solution of lidocaine and epinephrine in the mastectomy plane at the level of the superficial breast fascia. This assists in both hydrodissection of the correct plane as well as with hemostasis. The oncologic surgeon will then proceed with mastectomy, which should proceed at the level of the superficial breast fascia to maximize oncologic resection while preserving subcutaneous tissue and minimizing damage to the mastectomy skin flaps.⁷ Especially in cases such as one-stage implant-based breast reconstruction in which the ultimate reconstruction is exquisitely dependent on the quality of overlying mastectomy flaps, it is recommended that the plastic surgeon be present and involved with their breast surgical oncology colleagues in this regard.

Once the extirpative portion of the procedure is completed, the reconstructive surgeon should assess the operative field for the quality of the mastectomy flaps and underlying chest wall musculature. Traumatized or overly thin skin flaps warrant an adjustment in surgical plan in which a tissue expander should be favored in place of a one-stage reconstruction. The possibility should be discussed preoperatively with all patients. Intraoperative tissue angiography may be utilized to supplement clinical assessment in equivocal cases to determine the viability of mastectomy flaps and aid decision-making. Damage to the pectoralis or serratus musculature indicates the potential need for adjunctive scaffold support.

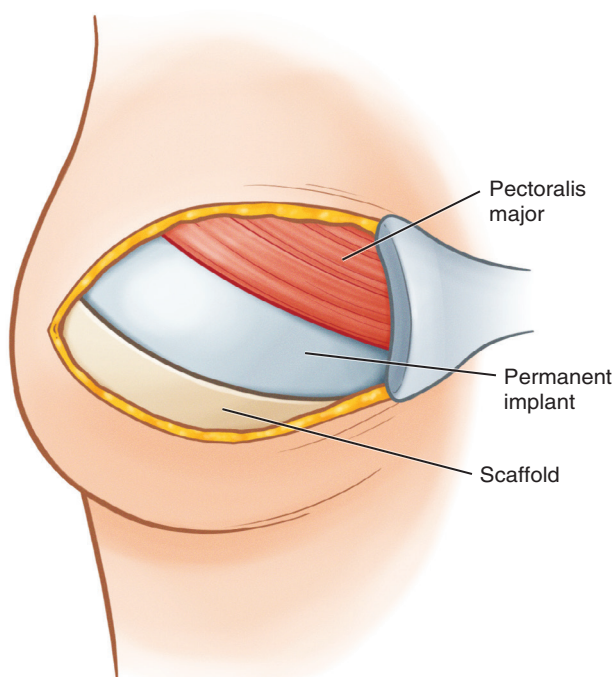
When the mastectomy flaps are judged to be healthy, immediate, permanent implant placement may proceed. The pectoralis major muscle is elevated from the underlying chest wall superiorly to the superior breast footprint and medially to the sternal muscular attachments. In rare cases of patients with small breasts, total submuscular implant coverage is possible. In these instances, the pectoralis is



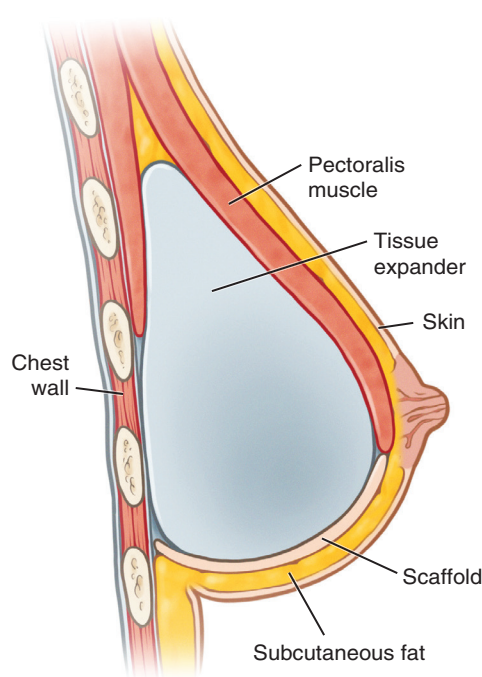
• **Fig. 9.2** Pre- (A,B), intra- (C), and postoperative (D) photographs of a patient undergoing immediate right one-stage implant breast reconstruction using a Wise pattern, skin reduction mastectomy incision with partial submuscular coverage and inferolateral coverage with an inferior pedicle adipodermal flap. A textured, round saline permanent implant was utilized. The mastectomy is performed through the superior triangular marking surrounding the nipple–areola complex. The inferior pedicle adipodermal flap is marked with hatched lines. After the mastectomy, the horizontal limbs are incised and the inferior adipodermal flap is de-epithelialized before the device pocket is developed. The patient also underwent a contralateral reduction mammoplasty.



• Fig. 9.2, cont'd



• **Fig. 9.3** Partial submuscular implant coverage with elevation of the pectoralis major muscle with inferior disinsertion and placement of acellular dermal matrix for inferolateral implant coverage and support.



• **Fig. 9.4** Sagittal diagram demonstrating partial submuscular implant coverage with scaffold placement for inferolateral implant coverage and support.

dissected inferiorly to the level of the inframammary fold, also elevating a variable portion of rectus abdominis fascia. The serratus muscle and/or fascia is elevated to the level of the anterior axillary line, followed by implant placement and suturing of the two muscular edges for implant coverage. Elevating only serratus fascia and sparing the muscle assists in minimizing muscular spasm and tightness postoperatively.

However, in greater than 90% of cases, adjunctive scaffolds are indicated for inferolateral implant support and

coverage to allow for expansion of the implant pocket to match the overlying breast skin envelope. In these cases, the pectoralis major muscle is elevated as previously described with the notable exception that the inferior attachments are released to the medial extent of the muscle. The scaffold is then sutured inferiorly to the inframammary fold and laterally to the chest wall at the level of the anterior axillary line. Our scaffolds of choice include ready-to-use contour fenestrated AlloDerm (Allergan, Dublin, Ireland) and Galaflex (Galatea Surgical, Lexington, MA) (Figs. 9.3 & 9.4). It is

our preference to use braided, permanent sutures such as Ethibond (Ethicon, Somerville, NJ) for affixing the scaffold to the inframammary fold and anterior axillary line.

At this time, antibiotic solution is utilized to irrigate the implant pocket and a saline sizer is inserted into the inner pocket with the mastectomy skin subsequently stapled. The patient is brought to a sitting position and saline is injected into the sizer to the point of producing an aesthetic breast footprint based on patient anatomy without yielding excess tension on the skin flaps, risking vascular compromise. Any contour irregularities can be marked and adjusted after the patient is brought back to a supine position. Often, the inferomedial corner of the pectoralis muscle may need to

be released to enhance the cleavage area or the anterior axillary/inframammary sutures adjusted to create the pleasing breast mound.

The appropriate implant is then selected based on the amount of saline in the sizer and is inserted underneath the pectoralis muscle using a no-touch technique. The muscular edge is then sutured to the edge of the scaffold. A drain is placed over the implant pocket under the mastectomy flaps and the mastectomy incisions are closed in a layered fashion after any devitalized skin edges are debrided. Long-acting local anesthetic solutions may be infiltrated through the drains to assist with postoperative pain control (Video 9.1).



Case Examples

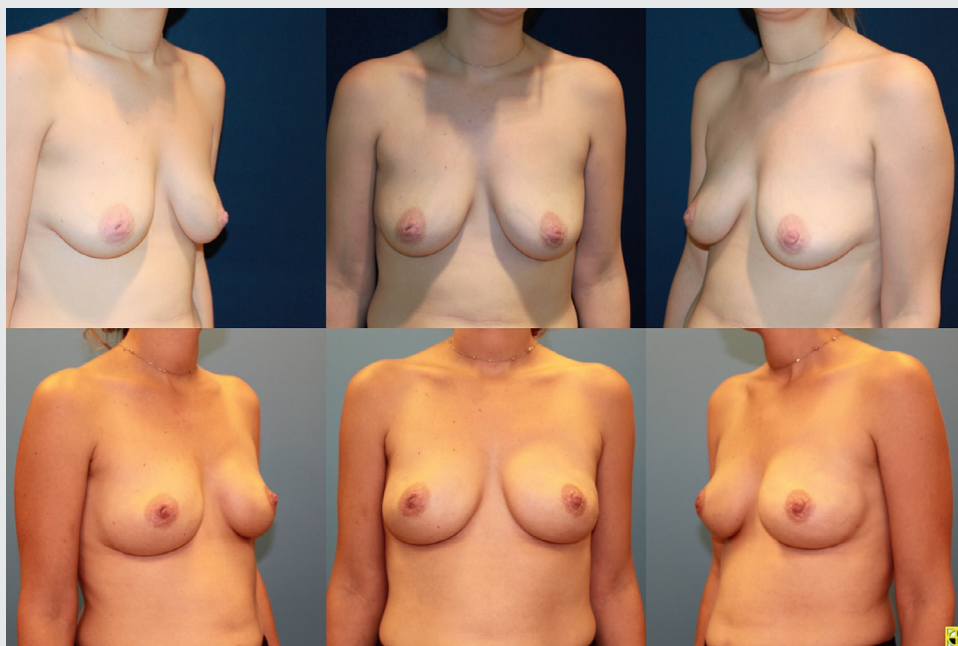
CASE 9.1

Case 9.1.1 shows pre- and postoperative images of a 32-year-old woman with mild grade I ptosis bilaterally with good nipple–areola complex position centered on the most projecting portion of the breast mound. She has good skin quality and elasticity. The patient desired a similar to slightly larger postoperative breast size, making her an excellent candidate for one-stage immediate implant breast reconstruction.

She underwent bilateral nipple-sparing mastectomy through inframammary fold incisions for high-risk prophylaxis with

immediate insertion of shaped, textured Natrelle Style 410 MF (Allergan, Dublin, Ireland) 375-mL permanent implants. The implant was placed in a partial submuscular plane using contour, perforated acellular dermal matrix. The sub-nipple area was sutured to the underlying muscle to elevate its position slightly.

Postoperatively, the nipple–areola complex position is maintained on the most projected portion of the reconstructed breast with minimal ptosis.



• Case 9.1.1

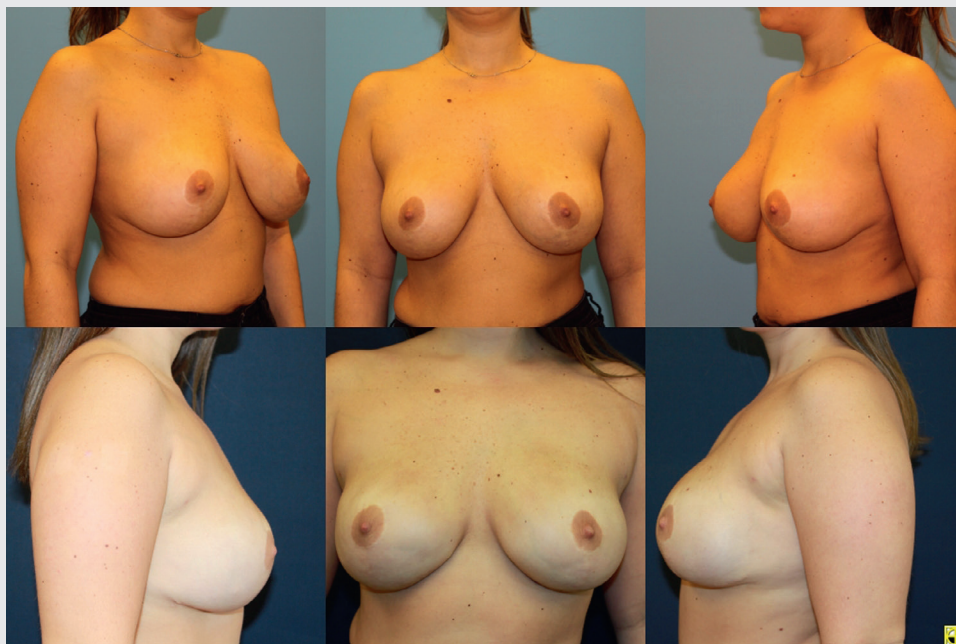
CASE 9.2

Case 9.2.1 shows pre- and postoperative images of a 28-year-old woman who underwent a remote, prior reduction mammoplasty using a Wise pattern incision, who presented for implant-based breast reconstruction with a plan for bilateral nipple-sparing mastectomy for high-risk prophylaxis. She has well-healed prior breast scars, good skin quality and elasticity, as well as no nipple–areola complex ptosis and mild glandular ptosis.

She underwent bilateral nipple-sparing mastectomy through inframammary fold incisions. She then had immediate

placement of smooth, round Natrelle Inspira SRX (Allergan, Dublin, Ireland) 525-mL permanent implants using a partial submuscular plane with contour, perforated acellular dermal matrix support.

Postoperatively, an aesthetic breast shape was achieved with a lateral footprint along the anterior axillary line. The inframammary folds are symmetric and there is no ptosis. The nipple–areola complexes have slightly lateralized; however, they remain positioned on the most projecting portion of the reconstructed breast.



• Case 9.2.1

CASE 9.3

Fig. 9.2 shows a woman with cancer of the right breast who presents for consultation of immediate unilateral breast reconstruction. She has undergone prior lumpectomy of the right breast with a scar in the upper, outer quadrant of the breast. She has grade III ptosis with laxity of the breast skin envelope. She strongly desires a one-stage implant-based reconstruction. Given her larger, ptotic breasts and laxity of the breast skin, an approach incorporating reduction of the skin envelope must be utilized.

The patient underwent right skin-sparing mastectomy with concurrent contralateral reduction mammoplasty. A Wise pattern incision was utilized from the skin-sparing mastectomy with maintenance of an inferior pedicle adipodermal flap. A partial submuscular plane was established via elevation of the

pectoralis major. A textured, round saline permanent implant was inserted underneath the muscle and covered inferiorly by the inferior pedicle adipodermal flap without the need for an adjunctive scaffold.

Postoperatively, the patient has an acceptable result with an aesthetic reconstructed breast mound that matches well with the contralateral breast. Note that the reconstructed breast is slightly smaller than the contralateral side as the permanent implant volume that can be placed is limited by the need to reduce tension on the overlying mastectomy skin flaps. If desired, the patient would undergo nipple–areola complex reconstruction 3–4 months after her initial reconstruction.

Postoperative Care and Expected Outcomes

Wounds are dressed with wound closure strips and non-adhesive gauze on top of which is placed an occlusive dressing. Drain exit sites are similarly covered. In cases of nipple-sparing mastectomy, the nipple–areola complex is dressed with antibiotic ointment, non-adhesive gauze, and an occlusive dressing. Parameters for inpatient discharge are adequate pain control on an oral analgesic regimen, ambulation, and adequate oral intake. Ambulation is encouraged on the day of surgery. These goals are generally achieved within the first two postoperative days. Patients undergoing unilateral reconstruction generally can be discharged on the first postoperative day while bilateral reconstruction patients may leave on the first or second postoperative day as able. Patients are discharged with pain medication and a muscle relaxant if a submuscular technique is utilized. Oral antibiotics covering skin flora are provided for one week given the inherent increased tissue stress and infection risk with immediate one-stage implant-based breast reconstruction.

Dressings are maintained for one week and removed on the first postoperative office visit. At this time, patients may wear a soft brassiere with no underwire. Drains are maintained until their output is less than 30 mL for two consecutive days. Patients may sponge bathe around the surgical sites until drains are removed. Patients are instructed not to lift anything greater than one pound in weight and to avoid strenuous exercise as well as lifting their arms above the clavicle level for four to six weeks. If no wound healing issues are encountered, patients may begin to wear non-underwire brassieres and scar management, including gentle massage, may commence after six weeks postoperatively.

Management of Complications

The most common complications after immediate one-stage implant breast reconstruction include mastectomy flap necrosis, nipple–areola complex necrosis, and infection (Table 9.2). Reconstructive failure is uncommon, demonstrated in the range of 2%–4% with both nipple-sparing and non-nipple-sparing mastectomy techniques.^{8–10} Less common complications include hematoma and seroma formation. Conflicting evidence exists regarding the comparative reconstructive risk of one- versus two-stage implant-based breast reconstruction with certain studies demonstrating higher risk with one-stage procedures while others describe equivalent outcomes.^{8,9,11,12} However, overall major complications are acceptably low with a recent study demonstrating that one-stage alloplastic breast reconstruction is the dominant reconstructive strategy with regards to cost–utility in appropriately selected patients.¹² Notably, older age and implant volume greater than 400 mL have been identified as independent risk factors for the

TABLE 9.2 Comparative Reconstructive Outcomes of Patients Undergoing Nipple-Sparing Mastectomy With One- Versus Two-Stage Implant Breast Reconstruction at NYU Langone Health

One-Stage	Two-Stage
Partial nipple necrosis: 7.8%	Partial nipple necrosis: 5.8%
Complete nipple necrosis: 3.9%	Complete nipple necrosis: 1.3%
Major infection (IV antibiotics): 1.7%	Major infection (IV antibiotics): 1.1%
Minor infection (oral antibiotics): 3.0%	Minor infection (oral antibiotics): 7.1%
Major mastectomy flap necrosis: 6.5%	Major mastectomy flap necrosis: 1.9%
Minor mastectomy flap necrosis: 12.9%	Minor mastectomy flap necrosis: 7.7%
Explantation: 3.4%	Explantation: 2.3%
Implant failure: 3.9%	Implant failure: 2.4%
Seroma: 0.4%	Seroma: 1.1%
Hematoma: 1.7%	Hematoma: 1.9%

(Adapted from Frey JD, Choi M, Salibian AA, Karp NS. Comparison of outcomes with tissue expander, immediate implant, and autologous breast reconstruction in greater than 1000 nipple-sparing mastectomies. *Plast Reconstr Surg*. 2017;139(6):1300–1310.)

occurrence of complications in one-stage implant-based breast reconstruction.²

Ischemic and infectious complications in one-stage implant-based breast reconstruction, as in all cases, should be diagnosed and managed aggressively to minimize risk of implant loss. Mastectomy or nipple–areola complex necrosis should be diagnosed early as partial or full thickness. Partial thickness ischemic injuries may be managed conservatively with local wound care. Deep partial or full-thickness ischemic areas should be addressed with early excision and primary closure, especially if the area is over underlying scaffold rather than muscle. Limited debridement and closure may be performed under local anesthesia in an office setting. However, larger necrotic areas may require explantation of the permanent implant and placement of a smaller implant or tissue expander. If any device needs to be replaced, general anesthesia is required. Debridement of the nipple–areola complex will necessitate secondary nipple reconstruction after complete wound healing.

Minor, superficial infection may be treated with oral antibiotics. However, severe or persistent infection will require intravenous antibiotics, possibly progressing to operative debridement and washout with device explantation or exchange. Hematoma occurs in 1%–2% of these cases and requires operative washout.⁹ Seroma, usually diagnosed as subacute, unilateral breast swelling, should be managed with percutaneous drainage and antibiotics to prevent potential bacterial seeding of the periprosthetic space.

Secondary Procedures

Having a preoperative discussion about realistic expectation is perhaps more important than the actual outcome in many aspects. Potential secondary procedures should be discussed at the time of the initial consultation such that patients understand that a one-stage implant reconstruction does not always signify that no future surgeries will be required. The revision rate in our practice is about 20%–30%.² Secondary procedures in one-stage immediate implant-based breast reconstruction are similar to those for two-stage techniques. Patients may seek contour correction for areas of volume deficiency, most commonly in the superior pole of the reconstructed breast, for which autologous fat grafting is a powerful adjunctive tool (Fig. 9.5). Capsule modification may also be required in cases of capsular contracture, implant asymmetry, or implant malposition. The need for such secondary revisions may be minimized with careful implant pocket creation at the initial procedure. Circumferential or directional capsulotomy is warranted in cases of circumferential or localized Baker grade I–III capsular contracture. Complete or partial capsulectomy is utilized when Baker grade III–IV capsular contracture is encountered.

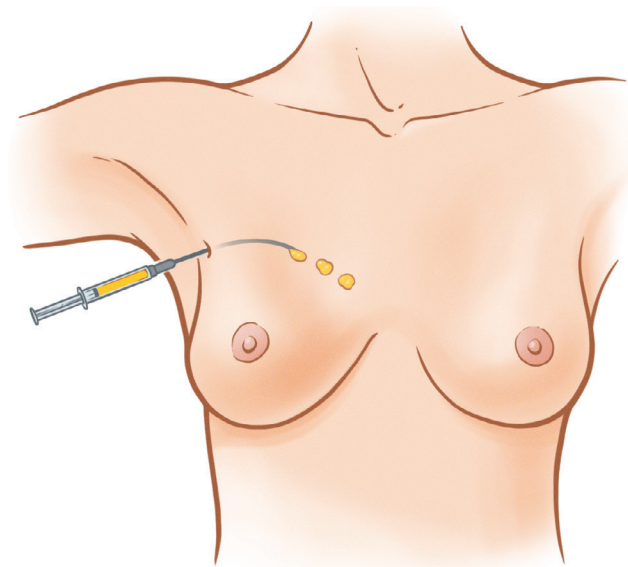
Cases of implant malposition secondary to capsule abnormalities are managed with combined capsulorrhaphy and capsulotomy/capsulectomy. Gravity and the action of the pectoralis major muscle will often cause these devices to fall laterally and inferiorly. Therefore, it is often necessary to perform a reinforcing capsulorrhaphy laterally combined with superior and medial capsulotomy to anatomically reposition the implant. Similar reinforcing capsulorrhaphy sutures may also be utilized to re-establish the inframammary fold in cases of inferior implant descent. A non-absorbable, braided, large-gauge suture is typically utilized

for these maneuvers. Notably, the implant capsule is removed prior to placement of capsulorrhaphy sutures to provide healing surfaces, which will be apposed to form a new, better-positioned implant capsule. Such patients are advised to avoid upper body exercise for two months postoperatively after capsulorrhaphy (Fig. 9.6).

Patients may also present postoperatively desiring a change in implant size. If a smaller size is requested, the permanent implant may simply be exchanged for a counterpart with less volume along with any other required revisionary procedures. If patients desire a marked decrease in volume that will result in a discrepancy of the overlying skin envelope with the new implant size, skin reduction may proceed using techniques similar to those employed for mastopexy. Patients requesting a larger breast size after immediate one-stage reconstruction must be approached cautiously. Patients desiring larger post-reconstruction breast size compared to pre-mastectomy size are better served with tissue expander–based reconstruction, allowing for safe expansion of the skin envelope to accommodate a larger implant volume. However, the breast skin envelope may slightly expand after a permanent implant is placed. A modestly larger implant may thus be exchanged in these patients if their skin envelope demonstrates adequate elasticity and thickness on examination (Fig. 9.7). In patients with good skin quality in whom a larger implant cannot be placed without undue tension, a tissue expander may be inserted followed by expansion and staged implant exchange. Patients with poor skin quality from such as irradiation desiring a larger implant size are better suited for combined latissimus flap reconstruction with implant exchange, providing healthy skin for implant coverage.

When nipple–areola malposition persists or presents in cases of nipple-sparing mastectomy, crescentic or directional excision techniques or mastopexy-type procedures can be utilized for correction, as discussed. In patients undergoing reconstruction after non-nipple-sparing techniques, nipple reconstruction may be performed 3–4 months after the initial reconstruction. If local flaps are utilized, the breast envelope will tighten to a variable degree based on flap design. Therefore, skin quality and elasticity should be assessed prior to nipple reconstruction. Flap design should then be designed to balance the competing interests of creating adequate nipple projection and minimizing skin tension over the underlying implant.

Lastly, in patients undergoing unilateral immediate one-stage implant breast reconstruction, contralateral symmetrizing procedures may be indicated. Often, patients undergoing reconstruction with this technique have smaller and non-ptotic breasts, requiring contralateral breast augmentation. However, mastopexy or breast reduction techniques may also be utilized to achieve bilateral symmetry in certain patients. While contralateral symmetrizing procedures may be performed at the time of immediate reconstruction, they may be executed more precisely in a secondary manner either independently or concurrently with revisions of the reconstructed breast.



• **Fig. 9.5** Fat injection may be utilized for contour correction, most commonly in the superomedial quadrant of the breast, after immediate one-stage implant-based breast reconstruction.



• **Fig. 9.6** Patient who underwent bilateral one-stage immediate implant breast reconstruction after nipple-sparing mastectomy using lateral incisions (top row). Patient developed bottoming out and loss of the inframammary fold as well as breast footprint at one-year postoperatively (middle row). The patient underwent revision with capsulotomy and capsulorrhaphy to re-establish the inframammary fold. Acellular dermal matrix was also used to reinforce the inframammary fold at the time of revision.



• **Fig. 9.7** Patient who underwent bilateral nipple-sparing mastectomy through inframammary fold incisions with two-stage implant-based breast reconstruction. Her tissue expanders were then exchanged for 425-mL Allergan style 410 FF textured, anatomic permanent implants (top row). Postoperatively, she required medicalization of the nipple-areola complexes and desired a change to smooth, round implants; thus 600-mL Allergan style 20 implants were placed (middle row). After her initial implant exchange, she desired a slightly larger breast size and demonstrated adequate skin quality and thickness on pinch test. Therefore, she underwent bilateral implant exchange for 700-mL Allergan Inspira SRX implants with a good postoperative outcome (bottom row).

Conclusions

One-stage implant-based breast reconstruction can provide patients with a reconstructed breast in a single procedure without the need for intermediate tissue expansion. Patients must be carefully selected as those with minimal breast ptosis and skin excess, healthy mastectomy flaps, and a desire for a smaller to slightly larger postoperative breast size. The favored technique involves partial submuscular implant coverage with inferolateral scaffold support fixated along the inframammary fold inferiorly and along the chest wall at the anterior axillary line laterally. Overall, one-stage immediate implant-based breast reconstruction offers reliable and aesthetic results when combined with appropriate patient selection and counseling.

PEARLS FOR SUCCESS

- Immediate one-stage implant breast reconstruction offers patients a reconstructed breast in a single operative procedure.
- When combined with nipple-sparing mastectomy, one-stage implant-based breast reconstruction offers a completely reconstructed “breast-in-a-day.”
- To optimize implant coverage, care should be taken to ensure mastectomy flaps are dissected at the level of the superficial breast fascia to maximize oncologic resection and preserve subcutaneous vascularity.
- Viability of mastectomy flaps should be carefully assessed intraoperatively before proceeding with immediate placement of permanent implants.
- When utilized, scaffolds should be sutured inferiorly at the inframammary fold and laterally along the chest wall at the anterior axillary line to provide inferolateral implant support and set the footprint of the reconstructed breast.
- Implant selection should be based on anatomic patient factors and patient preferences with an emphasis on minimizing final tension on the breast skin envelope.
- Any postoperative ischemic changes should be managed aggressively with debridement and primary closure, when possible, to minimize risk of implant loss.
- Older age and implant size greater than 400 mL have been established as risk factors for complications with one-stage implant-based breast reconstruction.
- Fat grafting and capsule modification may be utilized in secondary revision to augment and optimize results.

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10

Immediate Two-Stage Implant-Based Breast Reconstruction With Acellular Dermal Matrix

PING SONG AND LEE L.Q. PU

► Introduction

There continues to be a steady annual growth in breast reconstruction within the United States, with over 100 000 procedures performed in 2016 and a 39% increase in reconstructive breast procedures since the year 2000.^{1,2}

Immediate two-stage prosthetic breast reconstruction is well accepted in breast cancer reconstruction due to its impact on post-mastectomy body image and quality of life, as well as its safety and high patient satisfaction.³⁻⁵ Furthermore, in 2010, a national survey found half of all US-based plastic surgeons who perform implant-based breast reconstruction use acellular dermal matrix (ADM).⁶ As prosthetic breast reconstructions continue to increase, all plastic surgeons should be well versed in delivering a safe, consistent, and aesthetically pleasing result in this kind of reconstruction.

In the following chapter, the authors will focus on tissue expander-based immediate breast reconstruction with acellular dermal matrix as a first-stage implant-based breast reconstruction. Emphasis will be placed on surgical technique, as well as highlighting key concepts and pearls in tissue expander/ADM-based reconstruction.

Indications and Contraindications

Treatment planning for post-mastectomy breast reconstruction depends on several issues. Key indications for immediate breast reconstruction include the patient's oncologic disease burden as well as the need for adjuvant therapy. Immediate two-stage implant-based reconstruction is optimal in cases where adjuvant radiation therapy is not

required. Ideal candidates include relatively thin patients and patients requiring bilateral reconstruction (Fig. 10.1). However, the success and outcome of immediate implant-based reconstruction depends heavily on a reliable native soft tissue envelope. This can be achieved through a collaborative effort between the surgical oncologist and reconstructive surgeon. The two-stage approach also allows for precise recreation of the breast mound in terms of Inframammary fold (IMF) positioning, natural shape and final symmetry and is more flexible than one-stage implant-based reconstruction with fewer complications.

One absolute contraindication is ischemic or damaged mastectomy skin flaps. In this case a delayed reconstruction may be in the patient's best interest. Other contraindications include poor quality of the pectoralis major muscle, obesity, and tobacco use.

Benefits of ADM

Acellular dermal matrices have become ubiquitous in breast reconstruction. The benefits of ADM include improved inframammary fold control, better support and control of the pocket, greater intraoperative expansion with fewer subsequent clinic visits, and decreased risk of capsular contraction.⁷ There is also evidence to suggest a clinical benefit for patients who undergo subsequent radiation therapy,⁸ but the literature remains inconclusive and will benefit from further studies.

Additionally, by utilizing ADM as a tissue supplement over the inferior pole, further muscle dissection is spared, which leads to less postoperative pain, and a more anatomically precise pocket can be defined (Fig. 10.2). The higher-intra operative fill volume also addresses the retained skin in skin-sparing mastectomies. These benefits ultimately result in increased control by the surgeon over the reconstruction as well as final aesthetic outcome for the patient.⁹

Disclosure: The authors have no financial interest to declare in relation to the drugs, devices, and products mentioned in this article.



• **Fig. 10.1** A typical good candidate for immediate breast reconstruction. In general, patients should be healthy and not obese with moderate breast size and good breast skin condition.

Preoperative Evaluation and Special Considerations

During the preoperative visit, the overall quality of breast skin in each patient should be evaluated carefully. In addition, the presence of breast ptosis should also be evaluated. One important discussion to highlight in the preoperative setting with the surgical oncologist is mastectomy flap thickness. It is imperative to adhere to good oncologic principles during the ablation. However, it must be emphasized that immediate prosthesis-based reconstruction relies on healthy and viable tissue flaps, which are to be respected in order to optimize the reconstructive outcome.

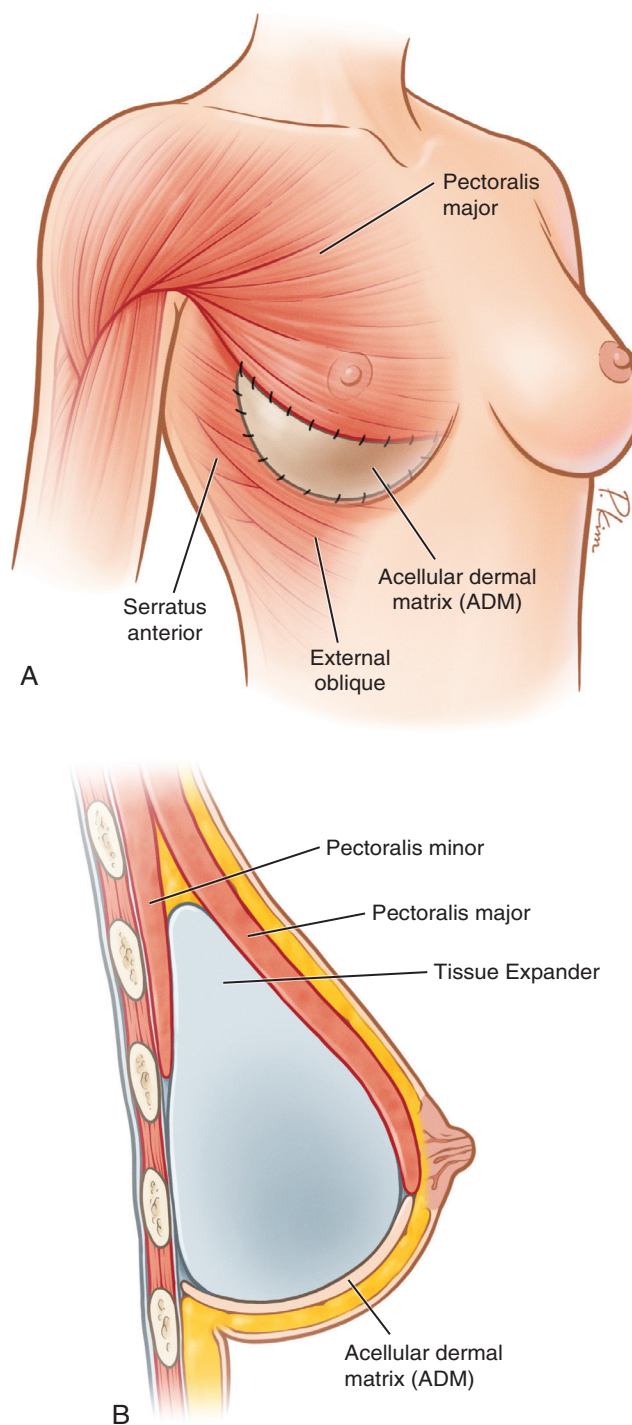
Skin-sparing or nipple-sparing mastectomy can usually be decided by the breast surgeon. The patient should be informed of the possibility of delayed reconstruction if the plastic surgeon deems the flaps are compromised. Additional considerations involve the impact of possible adjuvant chemotherapy and radiation therapy.

Surgical Techniques

Relevant Surgical Anatomy

The mastectomy defect can vary with the approach to the soft tissue envelope. The most important consideration is the viability of the remaining skin flaps (Fig. 10.3). As the skin relies on the dermal and subdermal plexus for its perfusion, any injury during the mastectomy from improper tissue handling or thermal cautery injury can lead to subsequent delayed wound healing or even reconstructive failure.

Once the breast parenchyma is removed, the pectoralis major muscle must be dissected free from its underlying attachments. This fan-shaped muscle has origins from the medial half of the clavicle, the sternum, the costal cartilage from the first to sixth ribs, and from the aponeurosis of the



• **Fig. 10.2** Schematic diagrams (A and B) showing the placement of ADM and created pectoral/ADM pocket in immediate breast reconstruction.

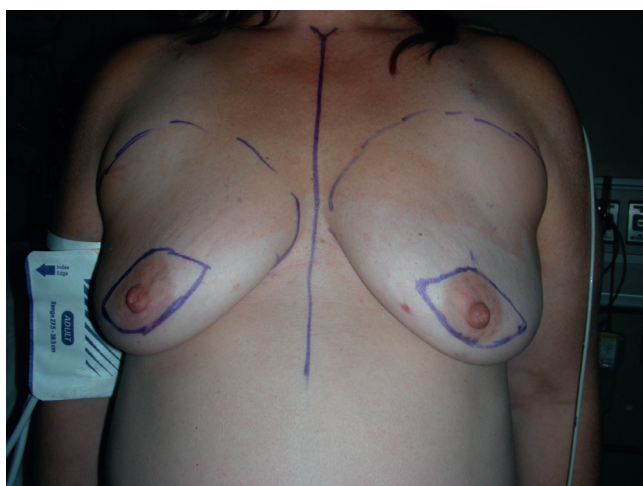
external oblique muscles. The fibers form two heads that course towards the insertion into the bicipital groove of the humerus. It is innervated by the lateral and medial pectoralis nerves and the blood supply is from the pectoral branch of the thoracoacromial artery. Deep to the pectoralis major muscle is its vascular pedicle, the pectoralis minor muscle and the chest wall and fibers from the external oblique. Care must be taken with dissection underneath the pectoralis



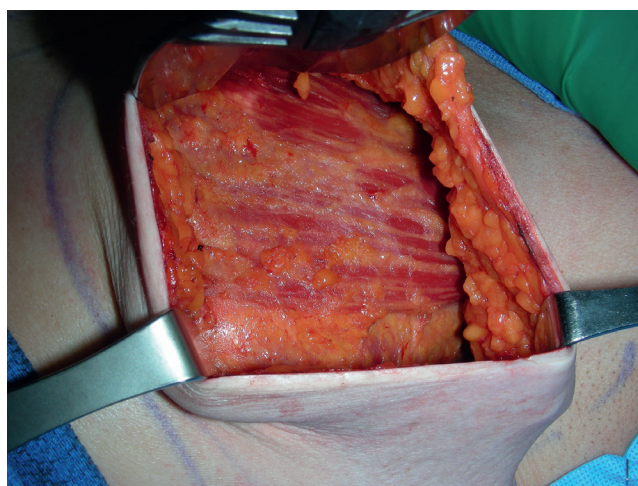
• **Fig. 10.3** A typical good example of the mastectomy skin flap after immediate skin-sparing mastectomy.



• **Fig. 10.5** Intraoperative view showing the appearance after skin-sparing mastectomy. The mastectomy skin flap is not compromised.



• **Fig. 10.4** A standard preoperative marking for a skin-sparing mastectomy patient.



• **Fig. 10.6** Intraoperative view showing the quality of the mastectomy skin flap and pectoralis major muscle after skin-spared mastectomy.

major muscle to avoid injury to the above structures as well as major perforators from the internal mammary arteries. Finally, it is wise to avoid cautery dissection directly on top of the ribs, as this will lead to increased postoperative pain.

Preoperative Markings

Prior to surgery, the patient is marked in the standing position. The anatomic landmarks include the sternal notch, midline, clavicle, inframammary fold, and anterior axillary line. Specific attention must be paid to the inframammary fold as the inferior border of the mastectomy. The inframammary fold along with the medial, lateral and superior borders of the breast are marked. The skin-sparing skin pattern is also marked (Fig. 10.4). Several options of expanders and acellular dermal matrix sizes are available but the final decision is made by the plastic surgeon intraoperatively after the mastectomy is completed. This ensures that each patient receives a reconstruction tailored to her individual needs.

Intraoperative Markings

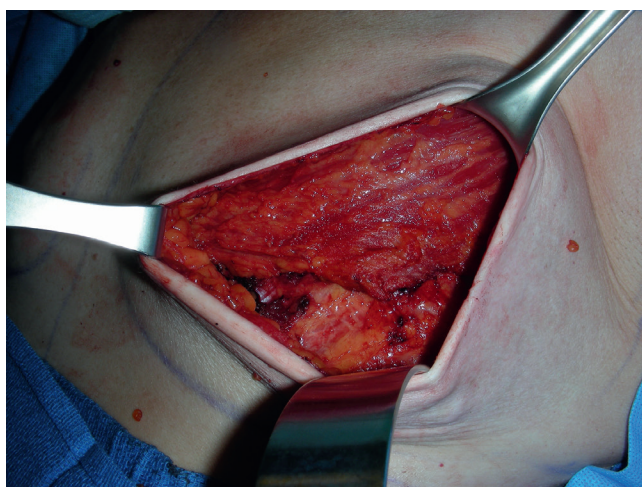
It is routine at our institution to begin reconstruction after the mastectomy is complete. The entire chest and axilla are re-prepped with betadine. It is always wise to inspect the mastectomy flaps for signs of thermal injury or full-thickness compromise (Fig. 10.5). Often this can be mitigated with direct excision, but the decision to proceed must be made at this juncture, as compromised skin flaps may compromise the reconstruction entirely. Skin perfusion imaging may serve as an adjunct to clinical exam in determining skin flap viability. In addition, the quality of the pectoralis major muscle should also be inspected (Fig. 10.6).

Next, the external breast border markings are transposed inside on top of the chest wall to help to restore the implant pocket. The two key areas are the inframammary fold and anterior axillary line, as this will define the dermal matrix sling and define the borders of the new breast. The transposed markings will also serve to guide suture placement for securing the ADM.

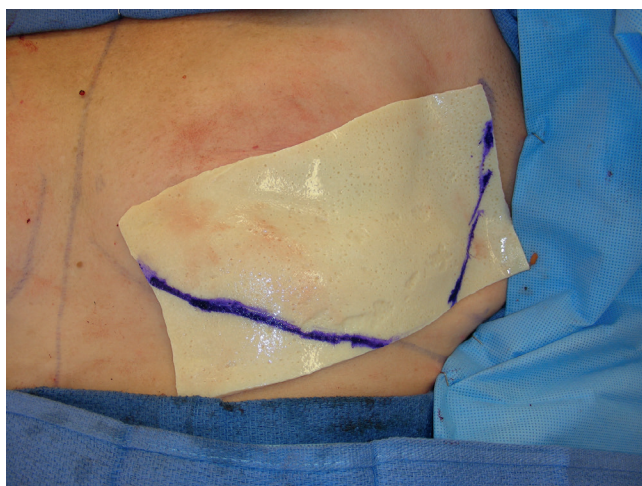
Details of the Procedure

Once the initial intraoperative markings are complete, the lateral edge of the pectoralis major muscle is identified. Using electrocautery, the dissection is started from the lateral extent. After the plane is identified between pectoralis major and the underlying chest wall, blunt finger dissection can be used to continue the dissection and elevate the muscle. It is common to encounter several perforators during the dissection, which should be cauterized.

Once the pectoralis major is sufficiently elevated (Fig. 10.7), the sizing of the ADM can be approximated. The senior author uses rectangular ADM measuring 16 cm×8 cm ultra-thick, and designs the matrix to lay parallel to the fibers of the pectoralis muscle. The excess corners of the dermal matrix are then cut to specification based on the preoperative markings along the IMF and lateral breast border (Fig. 10.8).



• **Fig. 10.7** Intraoperative view showing the elevation of the pectoralis major muscle and division of its lower attachment for creation of the muscle/ADM pocket.



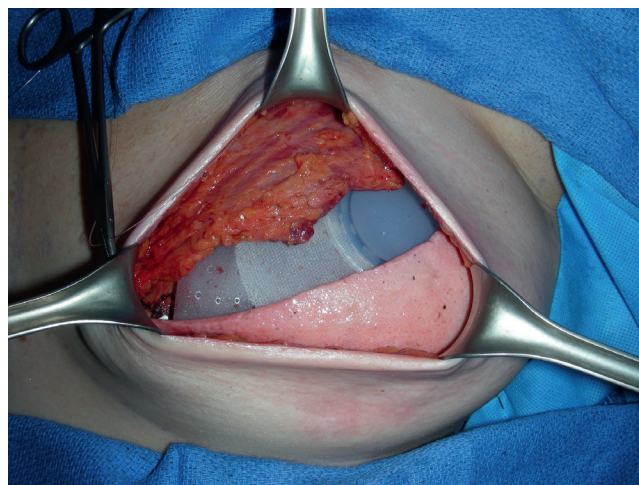
• **Fig. 10.8** Intraoperative view showing the plan for ADM placement as a sling for the lower and lateral poles of the muscle/ADM pocket.

Next, the ADM, with the dermal side facing up, is sutured in place using two 2-0 PDS sutures on a cutting needle. The steps of suture placement are key in ensuring precise pocket design, and are as follows. The first running suture begins in the inferior medial aspect; here the ADM is secured to Scarpa's fascia to recreate the fold as well as to the pectoralis muscle. The suture is run in a simple interrupted fashion laterally as outlined by the transposed markings. The suture is then anchored in the superior lateral aspect. A bite is taken from the ADM to the deep pectoralis muscle fascia and to the substance of the serratus anterior fascia. This three-part stitch helps to close the implant pocket from the axilla. The second suture will be used in the final step to close the pocket once the tissue expander is in place. Continued running of the first suture is done to recreate the lateral border of the pocket, ending where the second suture is anchored.

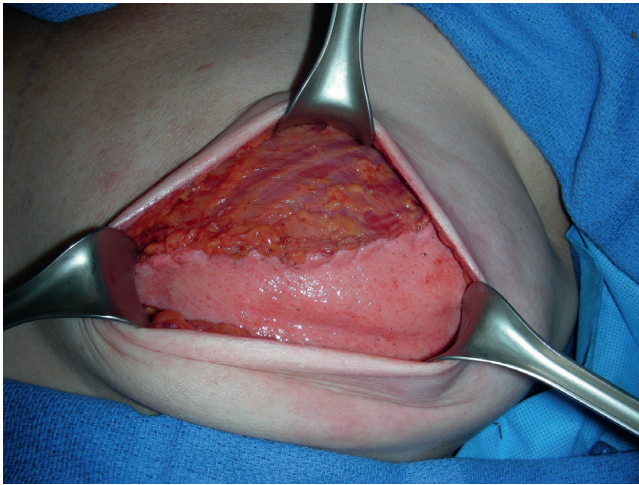
The pectoralis and ADM pocket is then thoroughly irrigated with triple-antibiotic solution. Next, an appropriately sized expander is prepared by removing the air, soaking in triple antibiotic solution, then placing it within the pocket with a no-touch technique (Fig. 10.9).

A medium high textured tissue expander is routinely selected in the senior author's practice for the first-stage implant-based breast reconstruction. The expander is filled usually to approximately 120 cc with methylene blue injectable saline solution. The second running 2-0 PDS suture is then run down the ADM–pectoralis interface to close the pocket. At this point, additional expander fill is performed to obtain a snug fit within the pectoralis–ADM pocket without compromising muscle perfusion or overlying skin perfusion (Fig. 10.10). In general, the expander can be filled to 50%–80% of its volume as long as mastectomy skin flap perfusion is not compromised (Fig. 10.11).

Two drains are left under the breast skin but above the pectoralis and ADM pocket on each side, which drain the inferior and lateral aspects, respectively. The overlying skin



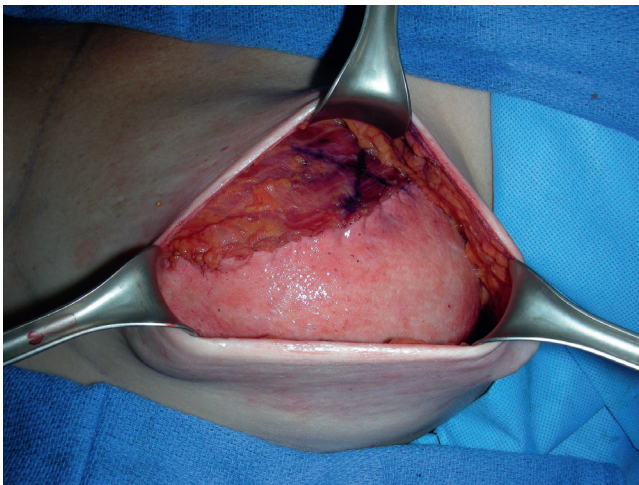
• **Fig. 10.9** Intraoperative view showing the completion of the muscle/ADM pocket and the placement of a tissue expander for immediate breast reconstruction.



• **Fig. 10.10** Intraoperative view showing the closure of the muscle/ADM pocket after the placement of a tissue expander with initial filling for immediate breast reconstruction.



• **Fig. 10.12** Intraoperative view showing the completion of the placement of a tissue expander for immediate breast reconstruction.



• **Fig. 10.11** Intraoperative view showing the completion of the placement of a tissue expander after additional filling for immediate breast reconstruction.

incision is closed in two layers with 3-0 Monocryl and 4-0 Monocryl (Fig. 10.12). Dressings involve gauze fluffs and a surgical bra to provide padding and gentle compression. Special considerations for immediate breast reconstruction are summarized in Box 10.1.

Postoperative Care and Expansion

All patients are discharged home with a soft surgical bra and on oral antibiotic regimen. Drains are removed once output decreases to less than 30 cc a day.

In the absence of delayed wound healing from ischemic flap complications, we routinely begin expansion at three weeks once the incision is healed. This allows for wound healing as well as initial dermal matrix incorporation and vascularization. Patients undergo, on average, 120 cc of fill each clinic visit every three weeks until we reach 20%–25%

• BOX 10.1 Special Considerations for Implant-Based Immediate Breast Reconstruction

- Proper determination of viability for mastectomy skin flap
- Reconstruction of IMF within the breast skin pocket
- Restoration of the same breast pocket size after mastectomy
- Creation of the pectoral/ADM pocket that is large enough and in proper position
- Adequate fill of a tissue expander as long as the breast skin is not compromised

over-expansion. Patients can be ready for the second-stage reconstruction involving permanent breast implant and tissue expander exchange in 2–3 months after the first-stage immediate breast reconstruction.

Second-Stage Reconstruction

The subsequent tissue expander to implant exchange occurs 2–3 months after the first stage. Through the initial incision, but limiting the length, careful dissection is carried down through the ADM–muscle layer. The expander is deflated via puncture and aspiration with suction. After removal of the expander, capsulotomy is usually needed medially or superiorly for further adjustment of the pectoralis–ADM pocket. Capsulorrhaphy can be performed using 2-0 PDS suture to prevent implant from lateral migration. The pocket is thoroughly irrigated with triple antibiotics and the new permanent implant is placed via Keller funnel. A high-profile smooth, round silicone implant is routinely selected to replace the tissue expander in the senior author's practice for the second-stage implant-based breast reconstruction. The incision is closed in three layers: the muscle–ADM is closed with 3-0 Vicryl suture, and skin closed with 3-0 and 4-0 Monocryl sutures.

Case Examples

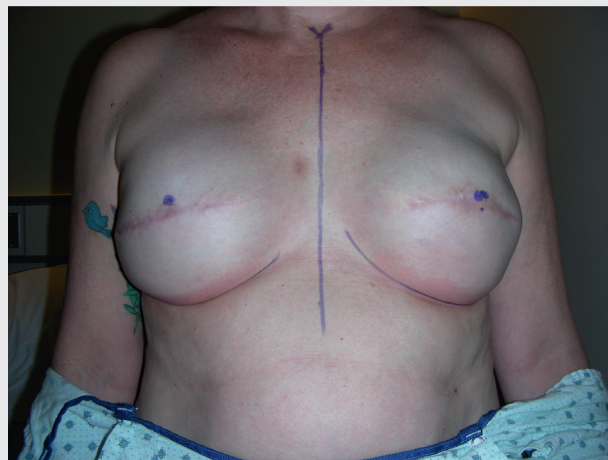
CASE 10.1

A 45-year-old white woman with an early stage of right breast cancer ([Case 10.1.1](#)) was offered bilateral skin-sparing mastectomies and immediate breast reconstructions with tissue expander ([Case 10.1.2](#)). After the mastectomy, she underwent a tissue expander placement within the pectoral muscle/ADM pocket for each side. Her tissue expander (450 cc) was filled to 300 cc initially. Her tissue expander was fully expanded within 2 months postoperatively and she

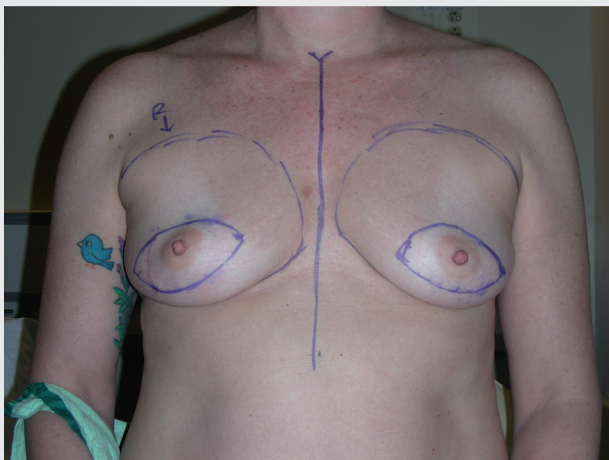
underwent the second-stage reconstruction with tissue expander/implant exchange and medial capsulotomy ([Case 10.1.3](#)). After successful placement of a permanent silicone breast implant (550 cc) ([Case 10.1.4](#)), she had nipple-areola complex reconstruction on both sides. Her entire postoperative course was uneventful. Results are shown 17 months ([Case 10.1.5](#)) and 58 months ([Case 10.1.6](#)) after initial breast reconstruction.



• Case 10.1.1



• Case 10.1.4



• Case 10.1.2



• Case 10.1.5



• Case 10.1.3



• Case 10.1.6

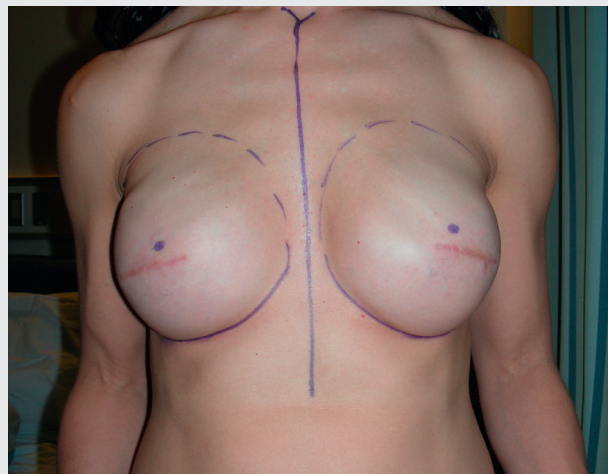
CASE 10.2

A 39-year-old woman with an early stage of left breast cancer (Case 10.2.1) was offered bilateral skin-sparing mastectomies and immediate breast reconstructions with tissue expander (Case 10.2.2). After the mastectomy, she underwent a tissue expander placement within the pectoral muscle/ADM pocket for each side. Her tissue expander (300 cc) was filled to 180 cc initially. Her tissue expander was fully expanded within 3 months postoperatively and she underwent the second-stage reconstruction with tissue expander/implant exchange,

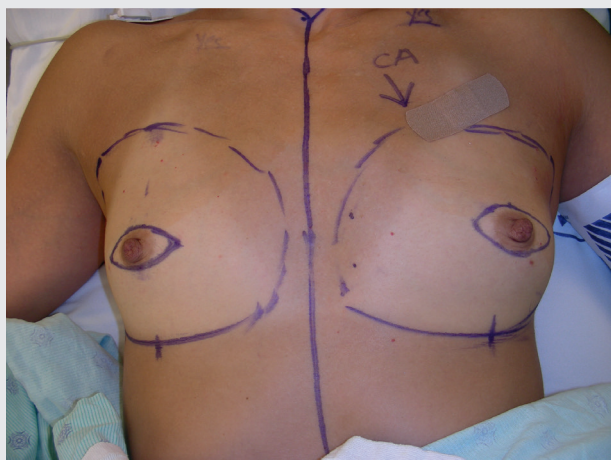
medial and superior capsulotomy, and lateral capsulorrhaphy (Case 10.2.3). After a successful placement of a permanent silicone breast implant (375 cc) (Case 10.2.4), she had nipple-areola complex reconstruction on both sides. Her entire postoperative course was uneventful. Results are shown 10 weeks after nipple reconstruction and 10 months after initial breast reconstruction (Case 10.2.5), and 10 months after nipple reconstruction and 16 months after initial breast reconstruction (Case 10.2.6).



• Case 10.2.1



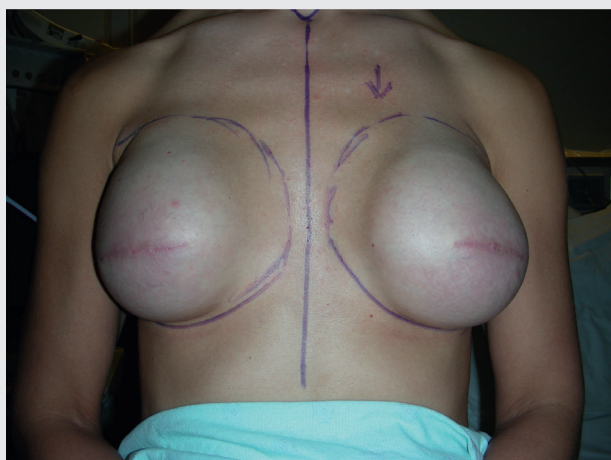
• Case 10.2.4



• Case 10.2.2



• Case 10.2.5



• Case 10.2.3



• Case 10.2.6

CASE 10.3

A 48-year-old white woman with an early stage of left breast cancer ([Case 10.3.1](#)) was offered bilateral nipple-sparing mastectomies and immediate breast reconstructions with tissue expander ([Case 10.3.2](#)). After the mastectomy through an inframammary approach, she underwent a tissue expander placement within the pectoral muscle/ADM pocket for each side. Her tissue expander (550 cc) was filled to 450 cc initially. Her tissue expander was fully expanded within 2 months postoperatively and she underwent the second-stage reconstruction with tissue expander/implant exchange and

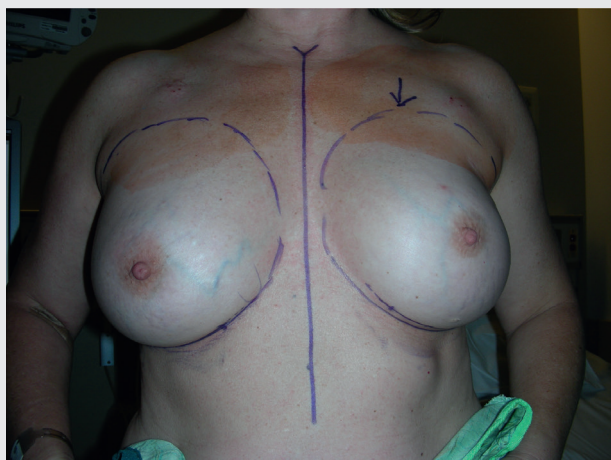
medial capsulotomy ([Case 10.3.3](#)). After successful placement of a permanent silicone breast implant (600 cc), she underwent two autologous fat-grafting procedures to improve the contour over her upper left reconstructed breast. Her entire postoperative course was uneventful. Results are shown 5 months after the first fat grafting and 12 months after initial reconstruction ([Case 10.3.4](#)), and 2 months after the second fat grafting and 17 months after initial breast reconstruction ([Case 10.3.5](#)). [Case 10.3.6](#) shows the result 24 months after initial breast reconstruction ([Case 10.3.6](#)).



• Case 10.3.1



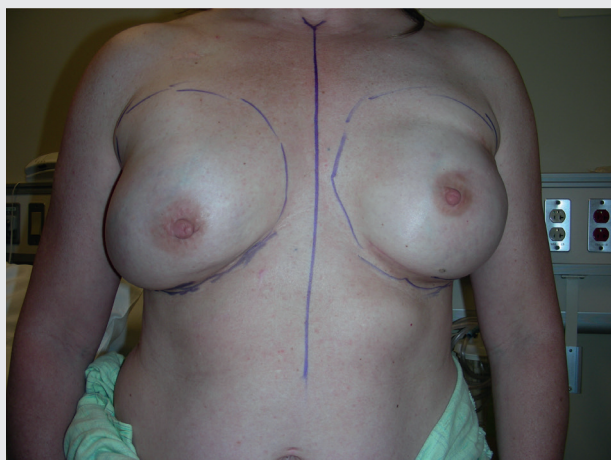
• Case 10.3.4



• Case 10.3.2



• Case 10.3.5



• Case 10.3.3



• Case 10.3.6

CASE 10.4

A 43-year-old white woman with an early stage of left breast cancer (Case 10.4.1) was offered bilateral skin-sparing mastectomies and immediate breast reconstructions with tissue expanders (Case 10.4.2). After the mastectomy, she underwent a tissue expander placement within the pectoral muscle/ADM pocket for each side. Her tissue expander (650 cc) was filled to 480 cc initially. Her tissue expander was fully expanded within 2 months postoperatively (Case 10.4.3) and she underwent the second-stage reconstruction with tissue expander/implant exchange and medial and superior

capsulotomy. After a successful placement of a permanent silicone breast implant (700 cc), she had her first fat grafting procedure to improve her upper breast contour on both sides and the result is shown at 17 months after the first fat grafting (Case 10.4.4). She then underwent nipple-areolar complex reconstruction on both sides and additional fat grafting to improve her upper breast contour (Case 10.4.5). Her entire postoperative course was uneventful. Results are shown 5 months after the second fat grafting and 60 months after initial breast reconstruction (Case 10.4.6).



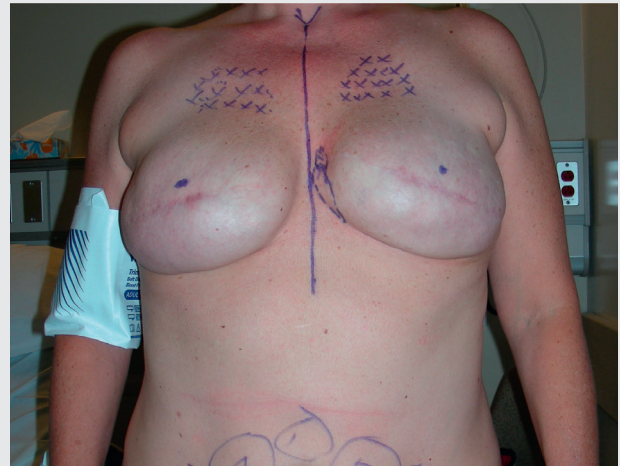
• Case 10.4.1



• Case 10.4.4



• Case 10.4.2



• Case 10.4.5



• Case 10.4.3



• Case 10.4.6

Management of Complications

In the senior author's experience, the majority of postoperative complications involve compromised skin perfusion. Partial skin flap necrosis and other threatened wound healing issues are often due to aggressive thinning and thermal trauma of mastectomy flaps and result in infection or expander extrusion. If skin edge necrosis occurs (Fig. 10.13A), the tissue expander can be deflated further and the necrotic portion of the skin can be excised (Fig. 10.13B) and the open area can be closed (Fig. 10.13C).¹⁰

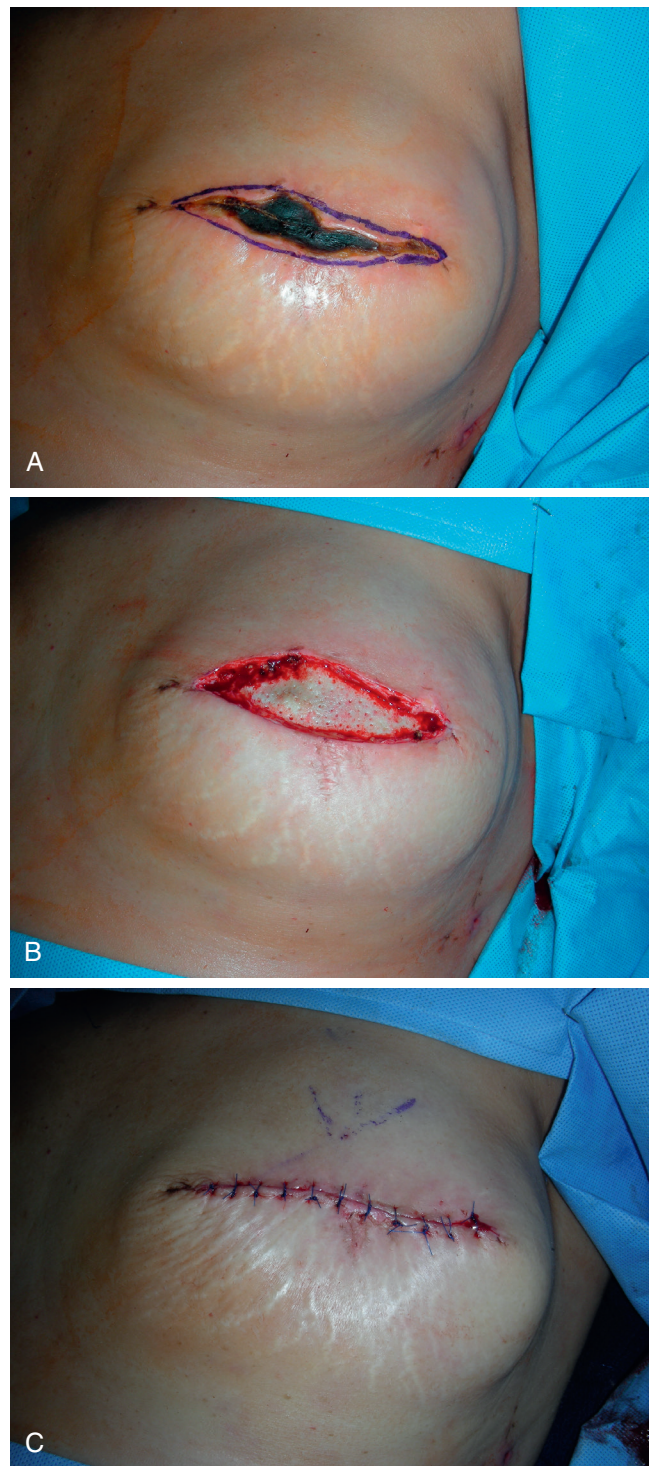
Another relatively common complication from immediate two-stage prosthetic breast reconstruction with acellular dermal matrix is seroma, which can be treated with needle aspiration. Infection is less common and is usually following skin flap necrosis or seroma. Treatment of infection includes intravenous antibiotics or removal of the tissue expander. In addition, red breast syndrome has been described in the literature and its management includes observation or oral antibiotics.¹¹ It is important to note that the use of acellular dermal matrices has been shown to increase certain complications (i.e., seroma). Evidence is inconclusive as to whether ADM increases overall complication rates after breast reconstruction,^{12,13} however with a judicious approach to flap viability, intraoperative fill, and postoperative expansion, it is our experience that many of these complications can be effectively managed.

Secondary Procedures

After the second-stage implant-based breast reconstruction, patients may present with several problems related to shape, size, contour, even symmetry of their reconstructed breasts. Implant malposition can be managed with reposition of the "old" breast implant after adjustment of the pectoral/ADM pocket and IMF position. A smaller size of reconstructed breast can be improved by an implant exchange with a larger size or different shape. Contour depression in the upper pole of the reconstructed breast can be treated with a series of fat grafting procedures. Excess skin or tissue over or around the reconstructed breast can be treated with direct excision or liposuction. Composite breast reconstruction can be performed with the same concept as composite breast augmentation by adding fat to an implant-based reconstructed breast so that the overall cosmetic result after implant-based breast reconstruction can be significantly improved in selected patients.¹⁴

Conclusion

Immediate two-stage implant-based breast reconstruction is a technique that every plastic surgeon should master. The advantages of incorporating acellular dermal matrix have allowed for more precise and consistently better reconstructive results. This chapter highlights the principles of a two-stage immediate breast reconstruction and describes a method for obtaining reliable and successful outcomes in appropriately selected patients.



• **Fig. 10.13** Intraoperative view showing (A) the outline of the necrotic mastectomy skin edges for possible excision, (B) the appearance after excision of necrotic mastectomy skin edges, and (C) the reapproximation for closure of the wound after excision of necrotic mastectomy skin edges.

PEARLS FOR SUCCESS

- Appropriate patient selection for implant-based reconstruction.
- Preoperative counseling regarding the postoperative course, including expansion and any potential adjuvant therapy.
- Attention to post-mastectomy skin flaps and the importance of healthy flaps.
- Design the subpectoral/ADM breast pocket correctly based on patient preoperative dimensions.
- Adequate intraoperative fill of the tissue expander should allow for a “hand-in-glove” fit within the new breast pocket and skin envelope.
- Tissue expander fill should be adjusted according to skin flap viability; do not compromise flap perfusion for greater expansion.
- In revision cases, common areas to address include capsulotomy for inadequate medial pocket and capsulorrhaphy for lateral pocket excess.

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Immediate Implant Breast Reconstruction With Total Muscle Coverage – Two-Stage

JONAS A. NELSON AND PETER G. CORDEIRO

Introduction

The rates of mastectomy and immediate breast reconstruction have increased over the past two decades, according to a number of large population-based datasets. Changes in the oncologic approach to breast cancer have contributed to increasing rates of bilateral mastectomies.^{1,2} Looking more closely at immediate reconstruction, the trends demonstrate increased utilization of implant-based reconstruction modalities, but a relatively constant rate of autologous reconstruction. Throughout this time, there have also been advances in breast implant technology that have significantly improved safety.

The most commonly used technique in implant-based breast reconstruction is two-stage, total submuscular coverage of the tissue expander in the subpectoral plane. The senior author (P.G.C.) of this chapter has had extensive experience in this reconstructive modality and has seen an evolution in his practice over the past 20 years.³ The purpose of this chapter is to discuss the lessons learned and to highlight the pearls and pitfalls of how to ultimately achieve a safe, reliable, and aesthetically favorable two-stage breast reconstruction.

Indications and Contraindications

There are few absolute contraindications for two-stage implant-based breast reconstruction. The main factors limiting the ability to perform reliable reconstruction include previous radiation therapy, smoking, and morbid obesity, all of which are considered by some to be relative contraindications.^{4,5}

Patients with a history of radiation therapy (whether for breast-conserving therapy necessitating salvage mastectomy or mantle field radiation) must be carefully examined to determine the impact of the radiation on the soft tissues. If the skin and underlying soft tissue are relatively supple with minimal fibrosis, a two-stage approach in a subpectoral

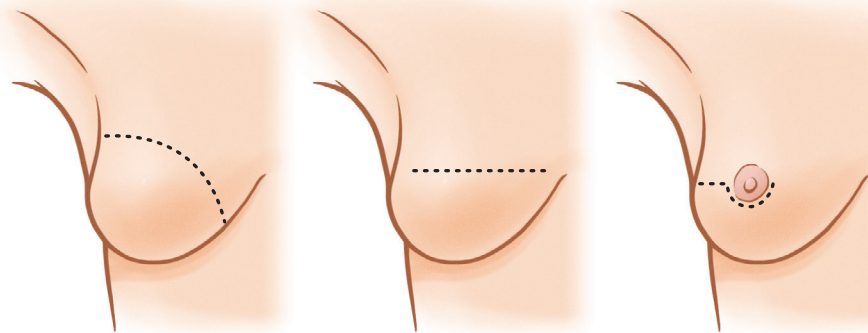
plane with total submuscular coverage can still be utilized. If, however, the skin and breast tissue have been significantly impacted by the previous radiation and the patient still desires implant-based reconstruction, using autologous tissue from a donor site to provide non-radiated coverage over the tissue expander may be the best option initially. In most cases, the latissimus dorsi is the optimum donor site for such coverage. Most importantly, a history of radiation therapy must be carefully discussed in the context of risk for postoperative complications, which is certainly increased.⁶ Managing expectations becomes very important given this increased risk.

Smoking and obesity both have the potential to impact the result and the reliability of implant-based breast reconstruction. Smoking influences mastectomy skin flap perfusion, which may already be tenuous. Obesity may hinder satisfactory aesthetic results with alloplastic materials, given the limitations in implant sizes. The risk of complications is certainly higher in this cohort overall as well. Our institutional approach is to assess these patients and discuss the risks with them. If they understand the risks, we often will proceed to surgery if they strongly desire breast reconstruction. In the setting of smoking, having total vascularized tissue coverage is even more critical, as this gives an added layer of vascularized tissue between the skin (which is tenuous) and the expander or implant.

Aside from the relative contraindications listed above, a significant comorbid profile may be the only other major relative contraindication to performing reconstruction. This is not, however, specific to total submuscular coverage in the immediate reconstruction setting and is a more generalized health risk decision point.

Preoperative Evaluation

Nearly all women who are scheduled to undergo mastectomy at Memorial Sloan Kettering Cancer Center meet with the Plastic and Reconstructive Surgery Service for a



• **Fig. 11.1** Mastectomy incisions. Initially, a superior oblique incision was used (left), but this has evolved to a horizontal (middle) or periareolar (right) incision (with lateral extension when needed). (© 2017, Memorial Sloan Kettering Cancer Center.)

consultation on all the methods of reconstruction, including the option for no reconstruction. A detailed history of the patient is taken with a focus on current diagnosis, previous breast surgeries, and history of radiation therapy to the breast or chest wall. A full physical examination is performed, with a focus on the breast. Preoperative asymmetry between breasts is noted and discussed with the patient, as well as the grade of mammary ptosis. If previously radiated, the pliability of the tissues is assessed. Standard breast measurements are obtained, including sternal notch to nipple, nipple to inframammary fold, breast base width, and nipple–areola complex diameter. Donor sites are assessed, including the back, lower abdomen, and inner thighs. A focused discussion about ideal reconstructive modalities follows the examination.

Prior to surgery and typically after the preoperative consultation, preoperative testing is performed in accordance with the American Heart Association (AHA) and American Society of Anesthesiologists (ASA) recommendations based on age and comorbidities. Patients with significant comorbid conditions should be cleared for surgery by their primary care provider or by a cardiologist who would perform the appropriate preoperative risk assessment.

Surgical Technique

All patients are marked in the preoperative holding area on the day of surgery. The midline meridian and the inframammary fold are marked on each breast to aid the breast surgeon with regards to the inferior resection. If skin-sparing mastectomy is performed, an ellipse of skin including the nipple–areola complex is also marked. Nipple-sparing mastectomy most commonly is performed with an inferior periareolar incision and lateral extension.

Mastectomy Incision

Over the past 20 years, the placement of the skin-sparing mastectomy incision has changed significantly from an oblique incision intended to avoid any visible scar along the

medial cleavage (Fig. 11.1).³ The oblique incision made the medial dog ear difficult to correct and prevented adequate expansion of the lower pole, which is an essential component of the two-stage approach. The incision has evolved to a horizontal incision with minimal medial extension. Such an incision allows the surgeon to tailor the mastectomy flaps, often extending the incision laterally to remove excess tissue, especially in a previously ptotic breast. This maximizes the amount of lower pole skin that can be expanded without an overlying scar.

The preferred nipple-sparing mastectomy incision is a periareolar incision with lateral extension. Our institutional experience has demonstrated good exposure and lower rates of nipple and mastectomy flap necrosis with this exposure. This incision also allows better access at the time of exchange.

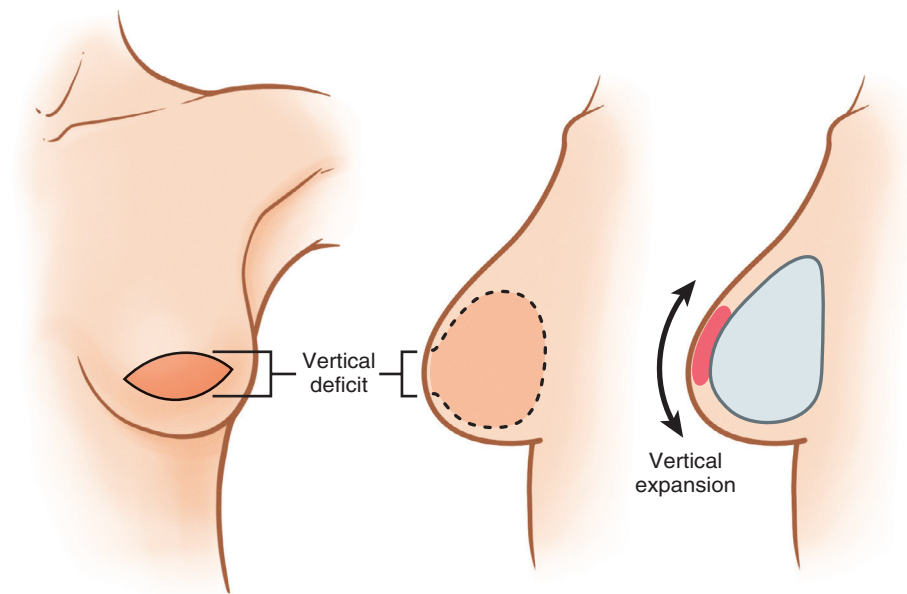
Mastectomy Defect

Following skin-sparing mastectomy, the skin defect is in the vertical dimension after removal of the ellipse surrounding the nipple–areola complex (Fig. 11.2). As a result, the majority of the expansion, preferably with full-height expanders, is focused on this vertical deficit. Full-height expanders maximize the overall volume and skin expansion in the vertical dimension. The base width of the expander is chosen based on the patient's breast base width, measured intraoperatively within the pocket following the mastectomy.

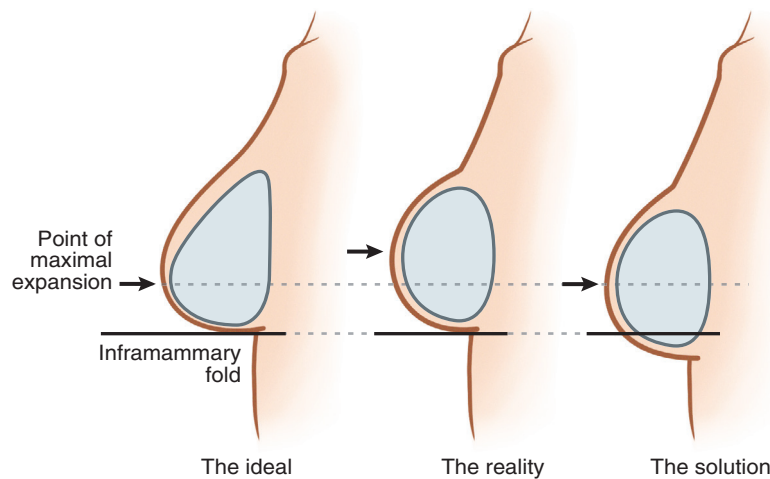
Tissue Expander Placement: Concepts and Operative Details

Point of Maximal Expansion

The point of maximal expansion in the reconstructed breast pocket must be in the lower third of the breast (Fig. 11.3). Over the past two decades, the senior author has seen an evolution in technique to achieve this ideal point of expansion. The ideal expander would be an anatomically shaped expander, which would be placed at the inframammary fold



• **Fig. 11.2** The mastectomy defect results in a vertical skin deficit. This vertical deficit is what must be addressed through expansion. (© 2017, Memorial Sloan Kettering Cancer Center.)

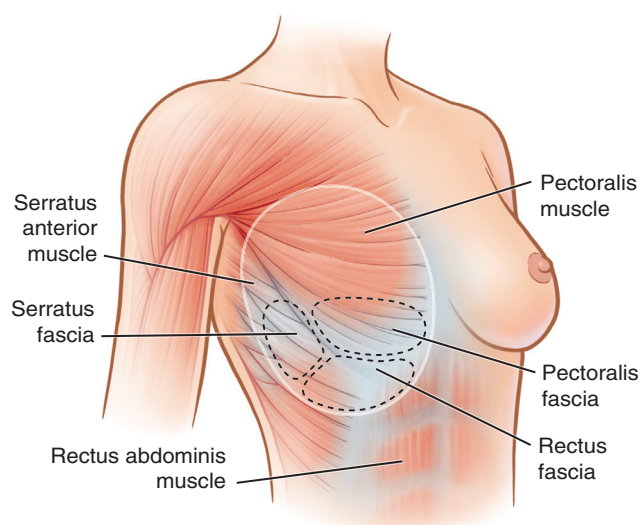


• **Fig. 11.3** The ideal point of expansion is in the lower third of the breast (left). Ideally, anatomically shaped expanders should achieve this point of expansion, but in reality, they result in expansion that is superior to this point (middle). Our technique has evolved, and we now place the expander 1–2 cm below the inframammary fold to account for this issue (right). (© 2017, Memorial Sloan Kettering Cancer Center.)

and then expanded in the lower third of the reconstructed breast. However, in reality, this placement causes expansion at a point slightly superior to this (too high), which at the time of exchange results in a reconstruction that appears constricted in the lower third of the breast. A reason for this may be that the chest tissues tighten around the expander as volume increases in the device, and the expander assumes a more rounded shape as pressure within increases. To address this, the device is now placed more inferiorly, minimizing upper pole expansion and maximizing lower pole precise expansion. The full-height expander is placed 1–2 cm below the inframammary fold. The medial boundary is 1–2 cm from the midline, and the lateral boundary is the anterior axillary line.³

Musculofascial Pocket

Historically, the approach to total vascularized coverage involved elevating the pectoralis major muscle medially and the entire serratus muscle laterally. This serratus muscle elevation often resulted in a painful surface area of exposed ribs for the patient and not ideally suited for sutures. This technique has now evolved from total muscular coverage to musculofascial coverage (Fig. 11.4). In musculofascial coverage, the superior aspect of the pocket is defined by the entire pectoralis muscle. Laterally, only a portion of the serratus muscle with all of its fascia is raised. Inferiorly, the insertion of the pectoralis is highly variable, at times being too high on the chest wall for appropriate positioning of the implant only underneath the pectoralis and the



• **Fig. 11.4** The musculofascial pocket with placement of the expander below the pectoralis muscle superiorly, in partial muscle/total fascial plane of the serratus anterior muscle laterally, and under the rectus fascia (then into the subcutaneous plane) inferiorly. (© 2017, Memorial Sloan Kettering Cancer Center.)

serratus. To address this, the inferior musculofascial pocket includes rectus fascia, which is raised in continuity with the serratus fascia. This approach has two main benefits: (1) the pocket provides structural support for long-term reconstruction and (2) the vascularized layer provides a protective layer to the expander and implant. This protection may prevent loss in the event of mastectomy flap necrosis or wound breakdown.

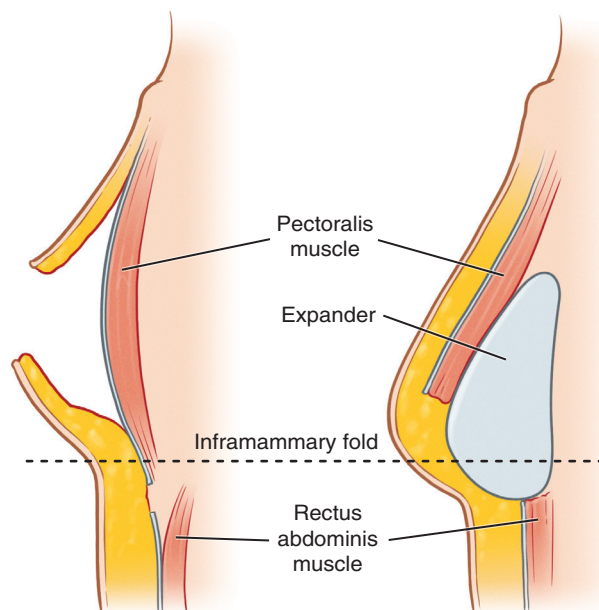
Inferior Fasciotomy

The inferior dissection is carried out 1–2 cm below the inframammary fold to achieve adequate expansion of the lower pole (Fig. 11.5). However, it was initially noted that this can be limited by a fascial band that lies across the lower pole. This compression prevents adequate expansion of the lower pole and can push the expander superiorly. To address this band, the dissection is adjusted to perform a curvilinear fasciotomy at or just below the inframammary fold. This places the expander superiorly in the submuscular plane and in the subcutaneous plane inferior to the fasciotomy. Once this fasciotomy is completed, it is important to manually assess the release to assure there are no remaining bands.

This overall approach with the musculofascial pocket and inferior fasciotomy has been a significant evolution in the technical approach to this procedure, and has maximized the aesthetic result in two-stage reconstructions. After the expander is placed, the pectoralis lateral edge is sutured to the serratus muscle, maintaining the anatomic location of both and preventing any window shading.

Intraoperative Expansion

After placement of the expander, we now fill approximately 50% of the total expander volume intraoperatively to decrease the postoperative expansion time and to also



• **Fig. 11.5** Diagram of the inferior fasciotomy to place the implant into the subcutaneous plane inferior to the inframammary fold. (© 2017, Memorial Sloan Kettering Cancer Center.)

decrease the risk of hematoma or seroma formation. This has evolved significantly over the past two decades. The total fill is determined by assessing the musculofascial pocket viability and mastectomy flaps. Closed suction drains are placed to prevent seroma or hematoma formation.

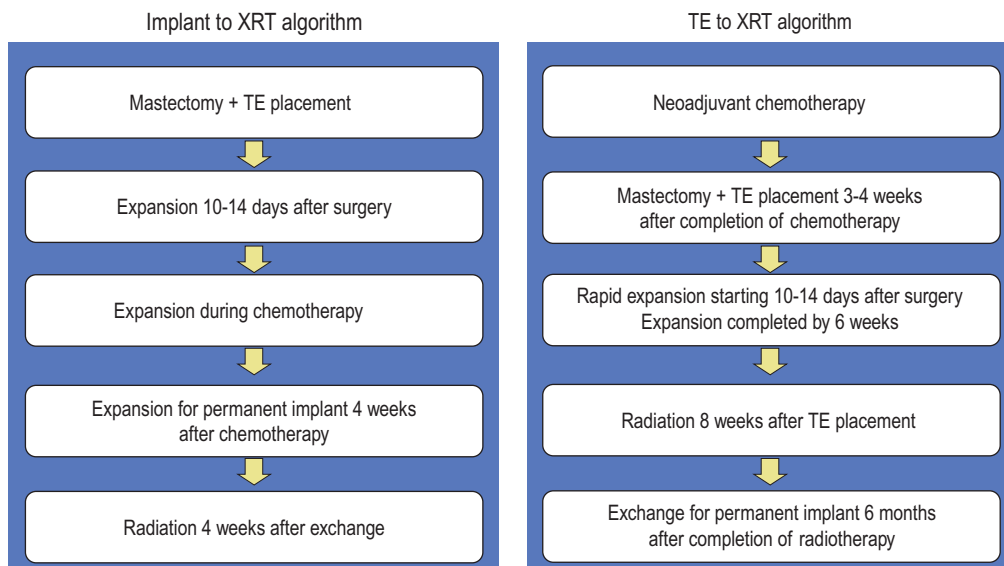
Postoperative Expansion

Over the past 20 years, postoperative expansion has been performed at increasingly shorter intervals after surgery. We now initiate postoperative expansion at postoperative day 10 to 14, at approximately the time the drains are removed. We generally expand 60–120 cc weekly, a total volume that is based clinically on the quality of the mastectomy flap and patient tolerance. While we once overfilled the expanders 50%–100%, we now overexpand the device by 10%–20%. This decrease in overfilling was secondary to observations that overexpansion was associated with rippling and excessive thinning of the skin, especially in the upper pole.

Exchange of Tissue Expander for Permanent Implant

Timing

The exact timing of the tissue expander exchange for the permanent implant depends upon the cancer treatment following the mastectomy. Generally, it is performed at least 6 weeks after the final expansion and 4 weeks prior to radiation therapy. A detailed protocol has been developed at Memorial Sloan Kettering Cancer Center to help guide surgeons through the process (Fig. 11.6). There are exceptions to these guidelines, which are loosely applied to most patients.



• **Fig. 11.6** Timing algorithms for two-stage implant reconstruction in the setting of post-mastectomy radiation therapy. Algorithms followed for patients receiving XRT after the permanent implant (left) and for patients receiving XRT after TE placement and before the permanent implant (right). TE, tissue expander; XRT, radiation therapy. (© 2017, Memorial Sloan Kettering Cancer Center.)

Our group recently examined this topic over a 9-year period.⁷ The analysis focused on 94 breast reconstructions with radiation to the tissue expander and 210 reconstructions with radiation to the permanent implant. Reconstructive failure occurred in 18% of the tissue expander radiation cohort and 12.4% of the implant radiation cohort (non-significant). The 6-year predicted failure rate was higher in the tissue expander radiation cohort compared to that of the implant radiation cohort (32% vs 16.4%, respectively, $p < 0.01$). Aesthetic results were significantly better in this cohort with higher risk, although Breast-Q scores did not differ.

Implant Selection

Towards the end of the expansion process, the surgeon and patient should discuss preference of final breast volume, contralateral balancing procedures, and the type of implant. The senior has continuously moved toward the use of anatomically shaped implants, as these tend to afford the best aesthetic result for breast reconstruction. Until 2006, the senior author used predominantly anatomic saline implants. When the moratorium on silicone implants was lifted and form-stable, cohesive silicone gel implants were developed, implant use shifted in this direction. These form-stable implants offered a greater variety of sizes, contours, and shapes. Furthermore, the cohesive gel is more likely to maintain shape and contour, with less rippling.

Anatomically shaped implants are chosen to have appropriate base dimensions (height and width) and to allow for appropriate projection. Base width is chosen to maintain the patient's base width measured at the time of the mastectomy and guides the initial tissue expander size. Final expanded volume is used as a guide for final implant volume. The main question at the time of exchange is the implant height and

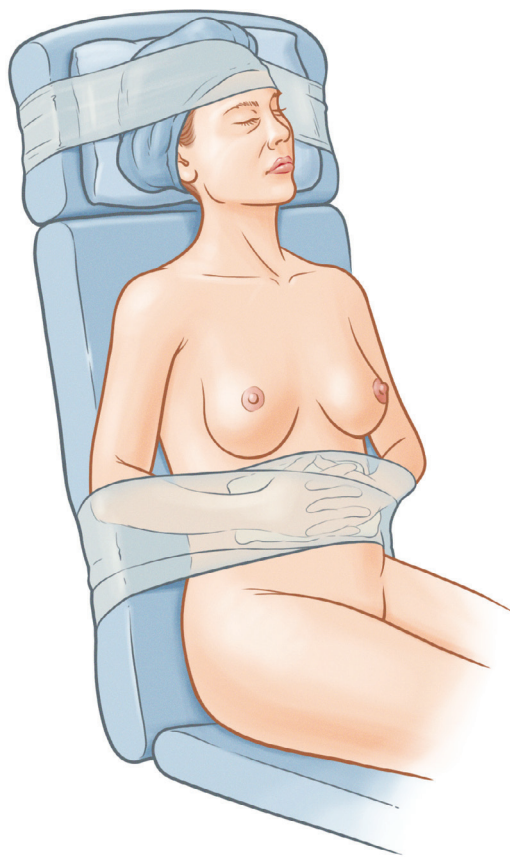
projection. Intraoperative use of sizers and experience help optimize selection and, ultimately, aesthetic outcome.

Setting the Inframammary Fold

The final exchange is performed with the patient in a seated position to afford the surgeon the ability to see the patient as she would see herself in a mirror (Fig. 11.7). The patient is placed supinely on the operating table. Following induction of general anesthesia, her arms and head are taped so she can be safely seated. Setting the inframammary fold is the key portion of the procedure, as the entire final reconstruction is based on this landmark. The fold is now reconstructed as the first major step of the exchange procedure. The inferolateral base of the breast is also reconstructed to prevent the implant from migrating towards the axilla. The expander is removed, and the fold is set with size zero silk sutures, fixing the deep dermis to the anterior chest wall. This chest wall stitch is typically to the capsule and soft tissue, and does not involve the periosteum. Several sutures are placed to set the shape of the fold and the inferolateral curve of the breast.

Circumferential Capsulotomy

The circumferential capsulotomy is the most important advance in the evolution of the exchange procedure. Initially, little capsule work was performed, releasing only where areas of stricture appeared evident. These limited capsulotomies usually resulted in herniation of the implant into the area of the capsulotomy as the remainder of the capsule continued to become more constricted and tight. As a result of this experience, a circumferential capsulotomy is now performed, which allows for anterior release and maximizes projection of the breast. This technique differs from radial scoring (Fig. 11.8).

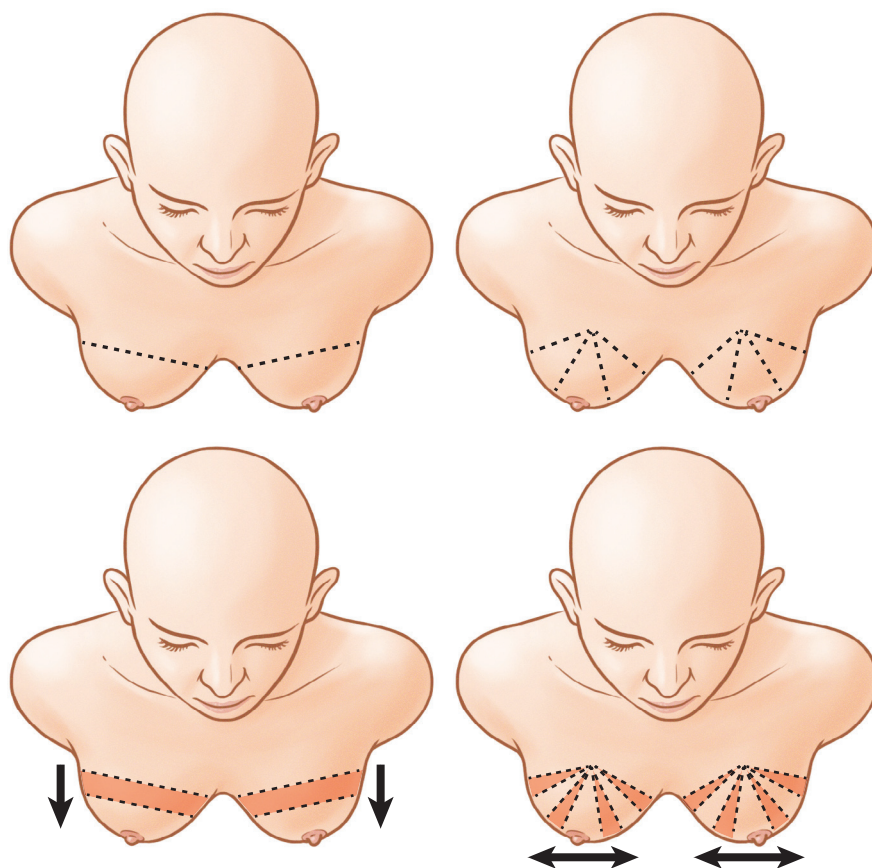


• **Fig. 11.7** Patient positioning and taping. (© 2017, Memorial Sloan Kettering Cancer Center.)

The capsulotomy is performed at the area of the capsule that is tightest. This is commonly at a distance of 1–2 cm from the chest wall, but varies by patient. The tightest portion within the same breast pocket can vary in the distance off of the chest wall. Special attention is paid to the lateral axillary region and the pectoral muscle inferomedially. This muscle may need to be released medially if it is too tight. The extent of release depends on the aesthetic evaluation of the medial breast contour. Scar in the axilla must be released, which is particularly bothersome in patients with irradiation and those who have had previous axillary dissections. It is then important to pull forward on the overlying musculofascial and cutaneous envelope to ensure circumferential release, which will accommodate and drape over the implant.

Sizers and Drains

The implant sizer mainly helps with assessing the implant size that the pocket will accommodate. It also affords assessment of the inframammary fold, the circumferential capsulotomy, and inferolateral breast boundary. It is essential when using anatomically shaped implants that the pocket fits snugly around the implant once it is placed. The sizer is chosen based on base width measurement and volume of the anticipated implant. After the capsulotomy is finalized, additional silk sutures are often placed at the inframammary fold and laterally to ensure a pocket that closely keeps with the final implant. The implant is then chosen based on the above characteristics, and the pocket is closed over a closed suction drain.



• **Fig. 11.8** Coronal view of circumferential capsulotomy (left, top and bottom) compared to radial capsulotomy (right, top and bottom). (© 2017, Memorial Sloan Kettering Cancer Center.)

Case Examples

CASE 11.1

Unilateral Mastectomy With Tissue Expander/Implant Reconstruction

A 54-year-old woman was diagnosed with left-sided breast cancer. She underwent a unilateral mastectomy with immediate tissue expander placement. She did not necessitate post-mastectomy radiation therapy. Her expander was exchanged for a permanent implant 4 months after the mastectomy, at which time a 470 cc anatomic, cohesive silicone gel implant was placed. She went on to have nipple-areola reconstruction and subsequent tattooing.

CASE 11.2

Bilateral Mastectomy With Tissue Expander/Implant Reconstruction

A 46-year-old woman was diagnosed with right-sided breast cancer. She underwent a bilateral mastectomy with immediate tissue expander placement. She did not necessitate post-mastectomy radiation therapy. Her expanders were exchanged for permanent implants 5 months after mastectomy, at which time 410 cc anatomic, cohesive silicone gel implants were placed. She went on to have nipple-areola reconstruction and subsequent tattooing.

Postoperative Care and Expected Outcomes

Dressings are minimized following both stages of the procedure. After the subcutaneous suture is placed, the patient

is cleaned and a dry dressing is applied without tape. The patient stays overnight for <23 hours following first-stage mastectomy and tissue expander placement. No pressure is applied to the tissue expanders to prevent any change in position. Exchange procedures are performed in an outpatient setting. Patients may not shower until incisions are healed and the drains are removed.

Complications

Complications following the senior author's initial 12-year experience with tissue expander/implant-based breast reconstruction were published in 2006,^{8,9} written as a two-part series looking at early (<12 months) and late (>12 months) complications. Early complications occurred in 8.5% of first-stage procedures, with skin flap necrosis (3.6%) and infection (3.1%) being the most common complications (Table 11.1). Expander loss or removal occurred in 1.8%. Following exchange, 2.7% of patients experienced a complication, the most common of which was infection. Risk of complications was significantly higher in first-stage reconstructions than in exchange procedures. Patients with a history of radiation therapy were at increased risk for total complications compared to those without radiation (11.7% vs 5.6%, respectively, $p=0.006$).

Long-term complications, including capsular contracture, rippling, and implant loss, were also assessed.⁹ Among patients with non-irradiated implants, 10% developed grade III/IV contracture. Twenty percent of patients with previously radiated implant reconstructions and 50% with reconstructions radiated after the exchange developed grade III/IV contracture. Moderate to severe rippling was seen in 6.6% of patients with form-stable anatomic implants, with 45.9% having no rippling. A negative relationship with capsular contracture and rippling was demonstrated.

TABLE 11.1

Perioperative Complications in Two-Stage Implant-Based Breast Reconstruction

	Expander Placement* (n = 1221)	Exchange Procedure* (n = 1055)	Total Primary Procedures (n = 2276)
Native skin flap necrosis	44 (3.6%)	1 (<0.1%)	45 (2.0%)
Infection	38 (3.1%)	20 (1.9%)	58 (2.5%)
Hematoma	7 (0.6%)	3 (0.3%)	10 (0.4%)
Delayed wound healing	6 (0.5%)	2 (0.2%)	8 (0.4%)
Seroma	3 (0.2%)	2 (0.2%)	5 (0.2%)
Failed expansion	2 (0.2%)	n/a	2 (0.1%)
Expander deflation	2 (0.2%)	n/a	2 (0.1%)
Systemic	2 (0.2%)	1 (<0.1%)	3 (0.1%)
Total complications	104 (8.5%)	29 (2.7%)	133 (5.8%)

* $p = 0.000$ for total complications after expander placement versus exchange procedure, McNemar's test.

(Adapted from Cordeiro PG, McCarthy CM. A single surgeon's 12-year experience with tissue expander/implant breast reconstruction: Part I. A prospective analysis of early complications. *Plast Reconstr Surg*. 2006;118:825.)

In long-term follow up, 4% of patients with permanent implants had them exchanged for a second implant. Satisfaction was also assessed, and 91.4% of patients stated they would choose the same method of reconstruction again.

A more in-depth, long-term examination of the impact of radiation demonstrated that implant loss occurred in 9.1% of patients with irradiated implants and only in 0.5% with non-irradiated implants ($p < 0.01$). Grade IV contracture was also more common in patients with radiated implants compared to those with non-irradiated implants (6.9% vs 0.5%, respectively, $p < 0.01$).¹⁰

Management of Complications

Early complications are typically treated conservatively to the extent possible. Patients with cellulitis infections are admitted and placed on intravenous antibiotics (2 g cefazolin) for approximately 48 hours until improvement is observed on physical examination. If there is no improvement, intravenous vancomycin is initiated. Once improvement is observed, patients are transitioned to an equivalent oral antibiotic and discharged after tolerating one or two doses. Skin flap necrosis is treated with dressing changes to keep the area dry.

Secondary Procedures

Following completion of the two-stage implant-based breast reconstruction, many women elect to undergo nipple-areola reconstruction. Our preferred method is utilizing a modified skate flap with full-thickness skin grafting and subsequent tattooing when necessary.¹¹ This method has low rates of complications and consistent results. Additional secondary procedures include fat grafting, dog ear excisions, and contralateral balancing procedures.

Long-term complications may necessitate revision in the operating room with implant exchange, capsulectomy, pocket revision, fat grafting, or, in very few instances, conversion to autologous reconstruction.

Conclusions

Two-stage implant-based breast reconstruction with total musculofascial coverage is a safe, reliable method of breast reconstruction with minimal early complications and good to excellent long-term aesthetic results in most patients. Radiation significantly impacts the risk of complications, but is not an absolute contraindication to this modality if there is appropriate preoperative counseling and patient selection. If complications occur, most can be treated without loss of the implant device.

PEARLS FOR SUCCESS

- Horizontal mastectomy incisions allow for tailoring of mastectomy skin flaps and removal of dog ears in acceptable locations.

- Total musculofascial coverage of the expander provides structural support of the device and forms a protective layer that allows for good expansion and prevents loss.
- The point of maximal expansion should be in the lower third of the breast. The expander is placed slightly below the inframammary fold, which requires a curvilinear fasciotomy through the musculofascial pocket into the subcutaneous fat at or just below the inframammary fold.
- Full-height expanders provide the best volume and distribution of expansion.
- Intraoperative expander filling to 50% of volume speeds up the expansion process and decreases the risk of seroma/hematoma.
- Setting the fold is a key component of the exchange procedure and is followed by circumferential capsulotomy, which maximizes projection of the breast.
- Sizers allow for assessment of the reconstruction prior to placement of the permanent implant.

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12

Immediate Prepectoral Implant Breast Reconstruction

ALLEN GABRIEL AND G. PATRICK MAXWELL

Introduction

Prepectoral implant-based breast reconstruction is a recent addition to the breast reconstructive armamentarium that is rapidly being adopted given its simplicity and reported potential benefits.¹⁻¹⁷ The technique involves placing the implant subcutaneously over the pectoralis major muscle, as opposed to under the muscle (subpectoral), which is the current established practice. By placing the implant over the pectoralis major muscle, the prepectoral approach preserves the anatomic integrity of the muscle as it is not dissected or elevated as in the subpectoral approach. With preservation of the muscle, the prepectoral approach eliminates animation deformity, pain, and muscle spasm that are often reported with elevating the muscle in the subpectoral approach.^{18,19} In addition, the prepectoral approach results in a natural-looking breast^{1,11} that anatomically resembles a native breast.

The prepectoral concept, however, is not a novel concept. Subcutaneous implant placement was attempted more than half a century ago when silicone implants were first introduced to the market. The technique, however, was soon abandoned when it became apparent that soft tissue coverage provided by the mastectomy flap alone was insufficient to support and maintain the implant above the muscle. Complications of bottoming out; implant migration; implant visibility, palpability, rippling, and wrinkling; and skin breakdown were, thus, common with this technique.

The renewed interest in the prepectoral or subcutaneous approach began after a number of technique and device advancements were introduced over the years in breast reconstructive surgery. Mastectomies became less aggressive, deviating from radical mastectomies to skin- and nipple-sparing mastectomies that preserved mastectomy flap perfusion and viability, which are critical for the prepectoral approach. Tissue perfusion devices became available that could assess perfusion in real time, providing an objective means of evaluating flap viability. The use of acellular dermal matrices (ADM) for lower pole soft tissue coverage in the dual-plane approach eventually led to the idea that the matrix could be used to provide total implant coverage,

obviating the need to elevate the pectoralis major muscle. Improvements in implant designs, such as the highly cohesive gel implants, which are associated with less rippling and wrinkling, meant that these complications which are concerns with prepectoral implant placement could be mitigated. Lastly, advances in autologous fat grafting techniques have permitted the use of autologous fat to provide additional soft tissue coverage that is often needed in the prepectoral approach to mask implant visibility and rippling. All of these advancements taken together are credited with making the prepectoral approach a reality.

The authors and others have shown that the prepectoral approach can be an effective reconstructive option,¹⁻¹⁷ but careful patient selection and meticulous technique are critical for successful outcomes. This chapter reviews the indications/contraindications and technique principles related to the prepectoral approach.

Indications and Contraindications

In general, ideal candidates for immediate prepectoral breast reconstruction are those who have a normal body mass index (BMI), small to medium breasts, minimal co-morbidity, and well-perfused mastectomy flaps. Many patients do not have this “ideal” candidate profile as they may be thin or obese or have mammary hypertrophy. This does not mean that prepectoral reconstruction is contraindicated in these patients but rather that it may be challenging to perform.

The availability of well-perfused, viable, mastectomy skin flaps is the single most absolute requirement for immediate prepectoral reconstruction. Given the proximity of the implant to the skin flaps, compromised skin flaps can result in skin necrosis which, in turn, may lead to infection, implant extrusion, and reconstructive failure. For this reason, any patient characteristic or factor that compromises flap perfusion or quality is considered a contraindication to immediate prepectoral approach. Thus, patient co-morbidities such as a BMI greater than 40 kg/m² (morbid obesity), uncontrolled diabetes (HbA1c >7.5%) and active smoking are all contraindications to the immediate prepectoral approach.

In addition, immunocompromised patients are also not suitable candidates because these patients are, in general, at increased risk of complications, particularly infectious complications. In patients with uncontrolled diabetes, prepectoral reconstruction can, however, be performed as a delayed procedure after controlling blood sugar with appropriate treatment. Likewise, obese patients (BMI >40 kg/m²) without prior radiation therapy can be considered for delayed prepectoral reconstruction.

Immediate prepectoral reconstruction is generally not recommended in patients who have undergone prior breast irradiation, particularly if the lumpectomy scar is in the lower pole.²⁰ Radiation damages the skin envelope and causes dermal thickening, thus increasing the risk of skin breakdown during the tissue expansion phase. Reconstructive options for these patients have traditionally relied on autologous approaches. However, an immediate, latissimus-based, prepectoral approach can be considered in these patients. The latissimus-based approach is typically performed in two stages (expander/implant), with or without soft tissue introduction with the flap depending on the need for supplemental soft tissue. The expander stage is critical in this approach to allow for skin and subcutaneous tissue expansion.

Post-mastectomy radiation therapy (PMRT), on the other hand, is not a contraindication to immediate prepectoral reconstruction. PMRT can be delivered to the expander or the implant as in the subpectoral approach. PMRT, in general, increases the risk of short- and long-term complications, including incisional dehiscence, infection, delayed healing, seroma, hematoma, capsular contracture, implant malposition/asymmetry, and reconstructive failure. Being cognizant of potential complications of PMRT is important as proactive management can improve patients' chances of a good outcome.

Lack of fat depots is another contraindication for immediate prepectoral reconstruction. This is of particular concern in thin patients. Thin patients have thin skin flaps that may not be adequate to mask implant visibility and rippling and require autologous fat grafting to improve aesthetic outcomes. However, alternative soft tissue fillers are an option in those without fat depots, in which case immediate prepectoral reconstruction can be considered. Further, highly cohesive gel implants are associated with less rippling and their use in thin patients may help reduce implant-related complications.

In addition to the reconstructive indications/contraindications, a number of oncologic factors also need to be taken into consideration when contemplating immediate prepectoral reconstruction. Patients with large tumors (>5 cm), posterior tumors lying near the pectoralis major muscle, chest wall involvement, axillary involvement, late-stage breast cancer, and a high risk of recurrence are not candidates for prepectoral placement. The oncologic safety of prepectoral placement in these cases is not known and it would be prudent to adhere to a conservative, cautious approach to breast reconstruction in these patients. In patients with axillary involvement and late-stage breast cancer (stage IV), aggressive adjuvant therapies may

be required which preclude the immediate reconstructive option.

It should be noted that the immediate reconstructive contraindications discussed above do not apply to delayed prepectoral reconstruction. In particular, flap viability and perfusion is not a requirement for delayed reconstruction. When considering patients for delayed prepectoral reconstruction, the overall health of the patient is taken into consideration.

Preoperative Evaluation

Patient selection for immediate prepectoral reconstruction is governed by preoperative patient characteristics, co-morbidities, neoadjuvant therapies, cancer stage, and tumor location as well as intraoperative mastectomy flap perfusion and viability. The patient's BMI, HbA1c status, and smoking history are assessed and information regarding cancer stage, tumor location, and neoadjuvant therapies are obtained from patient records. In the absence of contraindications, as outlined above, patient eligibility is ascertained provisionally. Following mastectomy, assessment of flap viability is performed intraoperatively. Prepectoral reconstruction is only offered if patients have well-perfused mastectomy flaps. As alluded to above, well-perfused mastectomy flaps are an absolute requirement for the immediate prepectoral approach.

Assessment of flap vascularity and viability is ideally performed objectively with the use of a tissue perfusion assessment device. Several of these devices are currently available, most of which use indocyanine green angiography to visualize arterial and venous flow in real time. These devices not only allow the assessment of tissue viability but also help identify areas of compromised perfusion, allowing their immediate excision to minimize tissue damage.

When a perfusion assessment device is not available or easily accessible, flap viability is ascertained by clinical assessment. Clinically, a well-perfused flap is recognized by bleeding incision margins and the presence of a layer of subcutaneous tissue under the flap. The latter is indicative of a preserved subdermal vascular plexus, which suggests the overlying flap is likely to be perfused and viable. A visible dermis under the skin flap suggests that the flap is too tenuous and not likely to be well perfused and viable. Skin flap thickness should not be used to assess for flap viability because skin thickness does not necessarily correlate to tissue viability.

In order to ensure the integrity of skin flap perfusion following mastectomy, a close collaboration with the general/oncologic surgeon is undertaken preoperatively. The general surgeon is briefed about the subsequent reconstructive approach so that aggressive mastectomies that compromise the vascularity of the mastectomy flaps are avoided as much as possible.

Surgical Techniques

Overall, the prepectoral technique is simpler than the subpectoral technique as chest wall muscles are not elevated.

Nonetheless, attention to technique principles pertaining to pocket to implant dimensions, acellular dermal matrix in setting, prosthesis dynamics, and aseptic conditions is critical for successful outcomes.

Following mastectomy and ascertaining flap perfusion and viability, the patient's internal breast dimensions are assessed in order to determine the size and dimension of the final implant. The final implant should fit snugly into the mastectomy pocket or prepectoral space. An implant that is smaller than the pocket creates dead space which increases the risk of seroma formation. Additionally, the lax overlying skin flap increases the risk of implant rippling and wrinkling. An implant that is larger than the pocket, on the other hand, places undue stress on the overlying flap and increases the risk of skin necrosis and its attendant consequences of infection, implant extrusion, and reconstructive failure. Reconstruction can be performed in one or two stages depending on patient preference, co-morbidities (BMI), and flap thickness. The advantage of the two-stage approach is that pocket adjustments can be made at the second stage, ensuring a snug fit of the implant that would otherwise have to be performed as a secondary procedure in the one-stage approach.

After establishing the implant dimensions, a footprint of the future breast is created by marking the position of the medial and lateral borders and inframammary fold on the outside and inside of the mastectomy pocket to help guide prosthesis placement. Attention is then focused on optimizing the pocket to accommodate the future implant. Subcutaneous tissue is repositioned to fill the spaces and collapse the pocket, as needed, to eliminate dead space. Dead space is more of a concern in obese patients and can be quite extensive following mastectomy. The removal of breast tissue in obese patients leads to the descent of large depots of lateral subcutaneous tissue to the posterior axillary line and the retraction of cephalad-subcutaneous tissue. The lateral subcutaneous tissue is displaced and secured to the anterior axillary line which collapses the pocket laterally. This decreases the risk of indentations that can form in these patients with thick subcutaneous tissue and decreases the risk of seroma formation laterally. The cephalad-subcutaneous tissue is displaced and secured caudally, which further collapses the pocket.

Acellular dermal matrix is integral to prepectoral reconstruction. The matrix is placed and secured over the entire anterior surface of the prosthesis. When used in this capacity, the matrix replaces the pectoralis major muscle, which is elevated to cover the prosthesis in the subpectoral approach. The matrix provides an additional layer of tissue support to the prosthesis and helps reduce the risk of bottoming out, prosthesis extrusion, inframammary fold malposition, rippling/wrinkling, and device visibility. It also mitigates the risk of capsular contracture and implant malposition in the long term. Typically, a single thick (2–3 mm) sheet of perforated acellular matrix measuring 16 cm × 20 cm is utilized for each breast. If using other sizes of matrix, two sheets may be required, which are sutured together with absorbable sutures to create one large sheet before inseting.

In all cases, the acellular matrix is prepared according to the manufacturer's specifications before use.

The technique of inseting of the acellular matrix varies depending on the incision location. In the case of an inframammary or lateral incision, the matrix is inset and secured to the pectoralis major muscle beginning superiorly and descending inferiorly on both sides toward the inframammary fold. Laterally, the matrix is secured to the serratus fascia while medially it is secured to the pectoralis major muscle. It is not secured inferiorly at this stage. The prosthesis is introduced into the pocket under the matrix through the inframammary fold incision and is secured directly onto the pectoralis major muscle via suture tabs. The matrix is draped over the inferior portion of the prosthesis and a 3–4 cm cuff is tucked under the prosthesis. The fold of the matrix is secured to the chest wall creating the inframammary fold. In the case of a transverse incision, the matrix is sutured inferiorly to the chest wall along the inframammary fold, leaving a 3–4 cm cuff toward the pectoralis major muscle. The prosthesis is introduced into the pocket and secured onto the pectoralis major muscle via suture tabs. The matrix is draped over the prosthesis and secured to the pectoralis major muscle medially and superiorly and to the serratus fascia laterally. The 3–4 cm cuff in both techniques serves to reinforce, stabilize, and define the inframammary fold and also support and stabilize the prosthesis and prevent bottoming out. In addition to these two techniques of acellular matrix placement, there are other techniques that utilize prefabricated prosthesis–matrix constructs. In these constructs, the prosthesis is completely covered anteriorly and to varying extent posteriorly with the matrix prior to its introduction into the mastectomy pocket. These “wrapped” constructs are currently not approved by the US Food and Drug Administration.

If using a tissue expander, it is partially inflated after insertion and before completion of securing the matrix. Typically, expanders are inflated to 50%–70% of maximum capacity with saline or air. Inflation with air is an off-label technique but is the author's preferred technique. As air is lighter than saline, it helps alleviate the pressure on the inferior mastectomy flap and minimize suture pull-through. Under-filling also helps to alleviate the pressure on the overlying flap, reducing the risk of ischemia, which is more of a concern with thinner than thicker flaps. Thinner flaps, in general, are more sensitive to compression. Real-time flap perfusion angiography can be used to guide intraoperative expansion and ensure that perfusion is not compromised. Under-filling, however, should not create dead space or compromise the apposition of the acellular matrix to the overlying skin flap. Adequate contact between the matrix and the skin flap is critical for matrix revascularization, recellularization, and incorporation into host tissue. However, the matrix should not be pulled taut over the prosthesis but should have some laxity to accommodate for subsequent tissue expansion. Typically a tissue expander with a base width that is 0.5–2 cm smaller than the base width of the final implant is utilized so as to ensure a snug fit of the final implant. In one-stage reconstructions, an implant that conforms to the exact dimensions of the future footprint of the

breast pocket is utilized and the acellular matrix is sutured taut over the implant without laxity.

In selecting the final implant for the prepectoral approach, implant cohesivity and/or fill capacity are important considerations. Form-stable, highly cohesive gel implants and high-fill implants are generally associated with less rippling and are thus the preferred implants in the prepectoral approach. Implant selection is a shared decision between the surgeon and the patient. As the shape and form of the reconstructed breast is dictated by the implant, the patient should be comfortable with the expected outcome. Surgeons should discuss the cohesivity of available implants and the trade-offs associated with using each implant type with patients.

Drains are essential in the prepectoral as in the subpectoral approach to reduce the risk of seroma. Seroma is of particular concern when using large pieces of acellular matrix. Typically two drains are placed between the matrix and the skin flap. Use of perforated matrices may further facilitate drainage and mitigate seroma risk.

In two-stage reconstructions, expanders are exchanged for permanent implants at about 3 months in patients who do not require adjuvant therapy. The expander is accessed preferably via an inframammary incision. After implant exchange, two drains are placed as in the first stage. At both stages, skin closure is performed in standard fashion in layers using absorbable sutures.

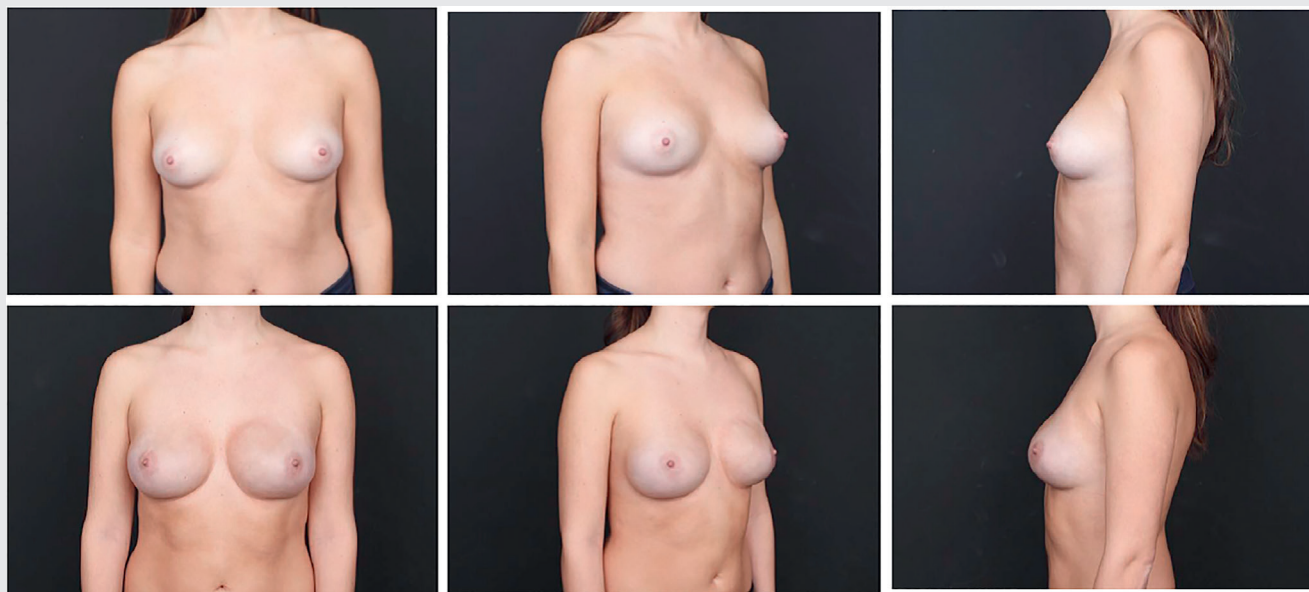
Strict sterile conditions should be maintained at all times during prepectoral reconstruction to reduce the risk of infectious complications. Following mastectomy, the prepectoral space is irrigated with a triple antibiotic cocktail (1 g cefazolin, 80 mg gentamicin, 50 000 IU bacitracin in 500 cc of normal saline) and again before prosthesis insertion. The prosthesis is also rinsed in the same antibiotic solution before insertion. Handling of the prosthesis is minimized and gloves are changed before handling the prosthesis. Antibiotics are administered pre-, intra-, and post-operatively to further mitigate the risk of infection per standard protocol.

Case Examples

CASE 12.1

Patient is a 36-year-old, BRCA-positive non-smoker with a BMI of 20 kg/m², without contraindications to immediate prepectoral reconstruction (no hypertension, diabetes, or prior history of breast irradiation). Despite her lean constitution, she was assessed to have adequate fat depots. Following bilateral nipple-sparing mastectomy, intraoperative assessment of flap perfusion revealed thin but well-vascularized mastectomy flaps and immediate prepectoral two-staged breast reconstruction was performed. As the risk of skin necrosis was a concern in this patient, extra precautions were taken to avoid compromising her flaps. Firstly, expanders were placed without intraoperative inflation so as not to place undue pressure on

the flaps. Secondly, a conservative approach to serial expansion was undertaken; that is, expansions were performed every 2 weeks rather than weekly. The longer interval between expansions allows flaps to recover and stabilize before the next expansion. Serial expansion was completed after initial surgery and expanders were exchanged for final implants (style 410LX 455 cc silicone implants). Although autologous fat grafting is usually offered to thin patients, in this case fat grafting was not performed at the patient's request. [Case 12.1.1](#) shows the patient preoperatively (upper row) and 18 months after second-stage reconstruction (lower row).



• Case 12.1.1

(Case 12.1.1 reprinted with permission from Gabriel A, Maxwell GP. Prepectoral breast reconstruction in challenging patients. *Plast Reconstr Surg.* 2017;140(6S):14S–21S.)

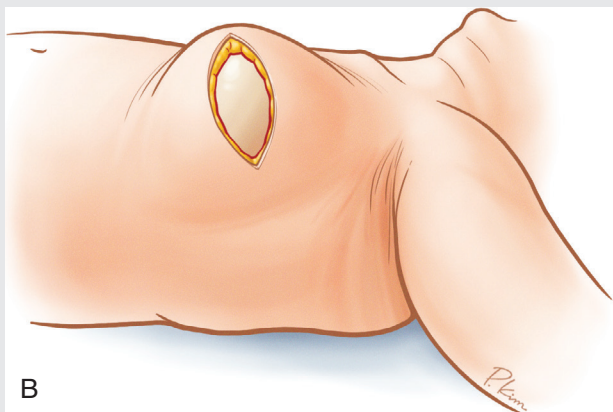
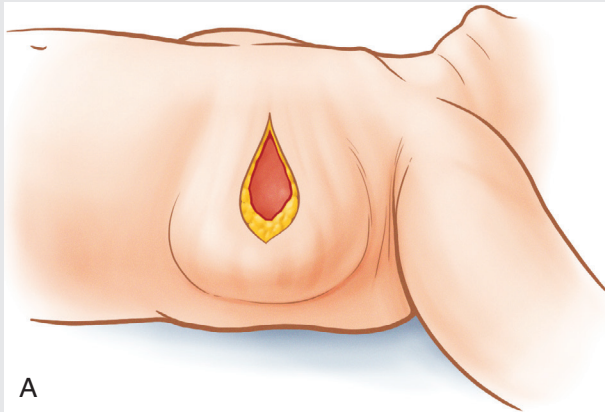
CASE 12.2

Patient is a 39-year-old, BRCA-positive non-smoker with a BMI of 48 kg/m², with normal blood pressure and without type 2 diabetes (HbA1c of 5.6%) or prior history of breast irradiation. Although a BMI >40 kg/m² is generally considered a contraindication for immediate prepectoral reconstruction, in this patient immediate reconstruction was undertaken.

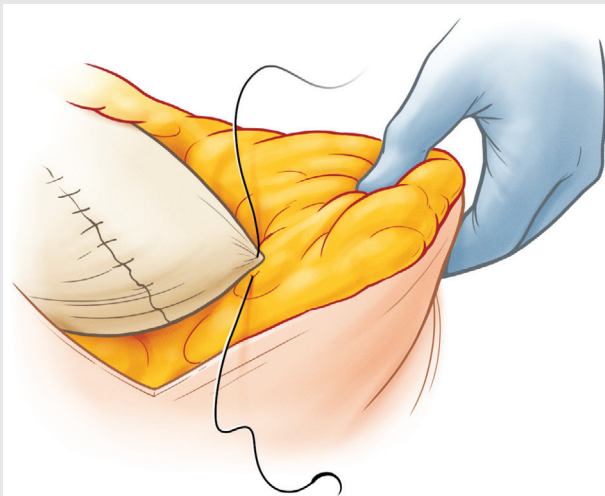
The two most important technical concerns in morbidly obese patients are extensive dead space and skin flap redundancy, both of which are manageable but require meticulous technique and time (Case 12.2.1). In obese patients, with the removal of breast tissue, large depots of lateral subcutaneous tissue fall posteriorly to the posterior axillary line. This subcutaneous tissue needs to be repositioned to the anterior axillary line. Likewise, the cephalad-subcutaneous tissue, which is retracted after mastectomy, needs to be repositioned caudally (Case 12.2.2). Repositioning of tissue in the prepectoral space serves to collapse the pocket and reduce dead space. Obese patients typically have redundant medial and lateral flaps following mastectomy. Skin flap redundancy can be addressed by a combination of skin-reducing mastectomy and utilizing the redundant flaps to reconstruct the new breast. The flaps are marked

preoperatively where the top of the vertical incision is going to be, utilizing the mid to lower third humerus as the landmark (Case 12.2.3). This is then reinforced after completion of skin-sparing mastectomy (Case 12.2.4). The expander ADM construct is placed and tailor-tacking is performed and the vertical limb is set at 9–10 cm on stretch and the horizontal component is added (Case 12.2.5). The flaps are de-epithelialized and the exposed dermal and subcutaneous fat layers are arranged over the acellular matrix to provide additional soft tissue coverage to the prosthesis (Case 12.2.6). Only well-vascularized redundant flaps are utilized and poorly vascularized areas should be excised. The vertical and horizontal components are then closed over the vascularized flap (Case 12.2.7).

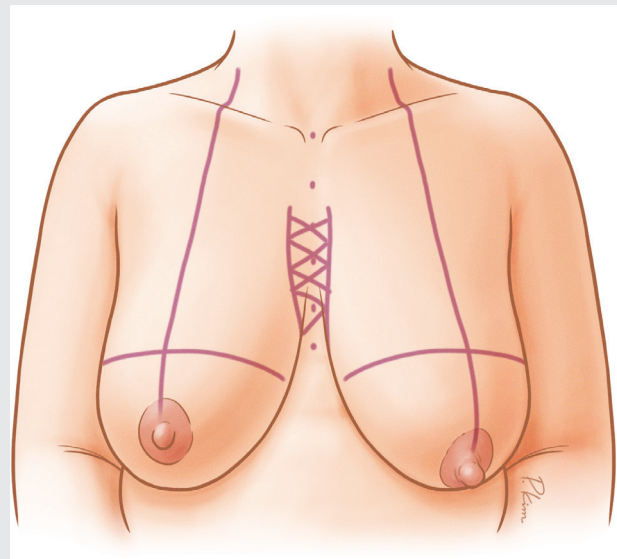
This patient underwent bilateral skin-reducing mastectomy followed by immediate prepectoral two-staged breast reconstruction with style SRX 800 cc silicone implants. One session of fat grafting and bilateral nipple reconstruction was performed at the third stage. Case 12.2.8 shows the patient preoperatively (upper row) and 20 months after second-stage reconstruction (lower row).



• Case 12.2.1

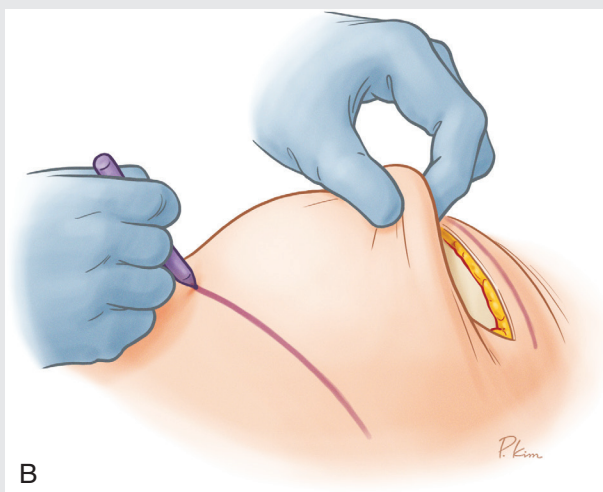
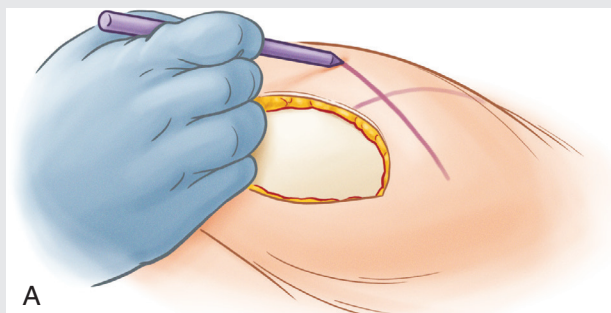


• Case 12.2.2

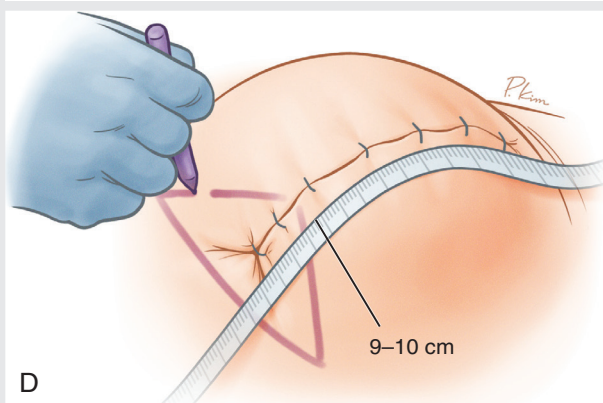
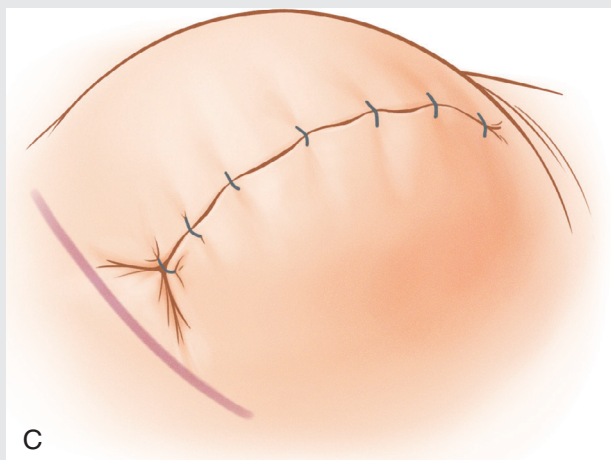
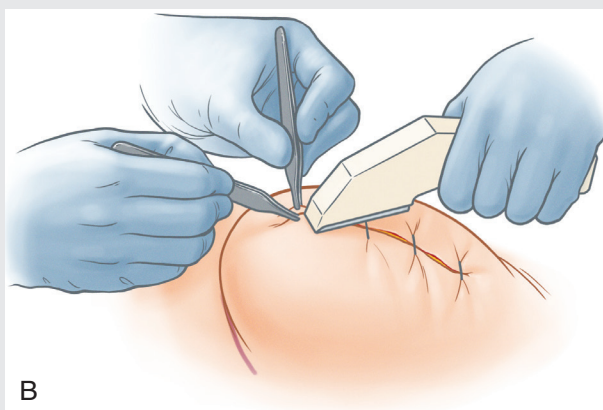
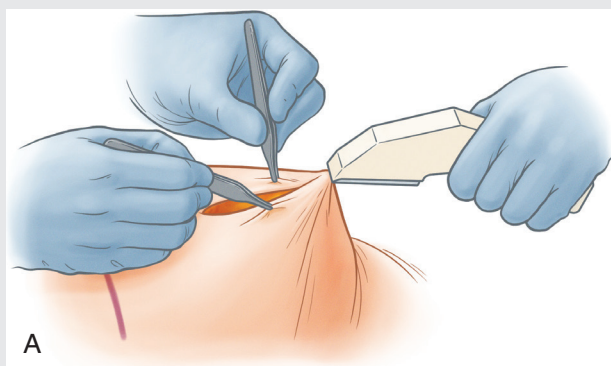


• Case 12.2.3

CASE 12.2—cont'd

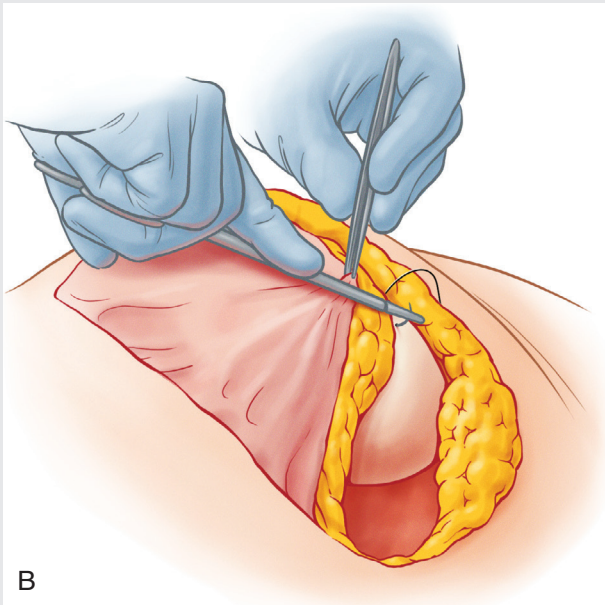
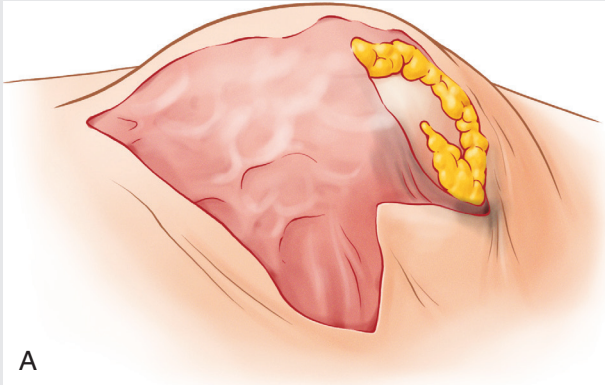


• Case 12.2.4

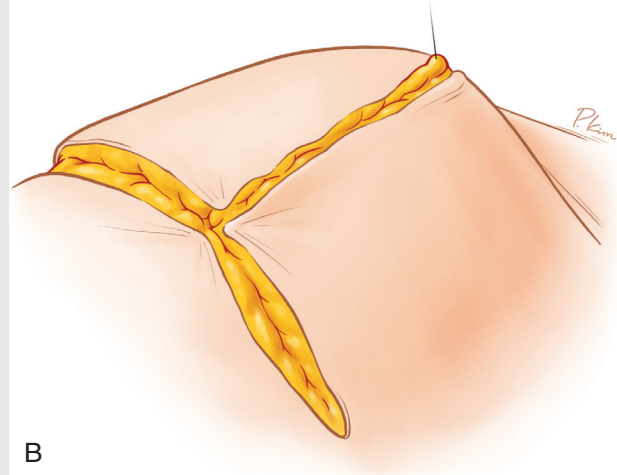
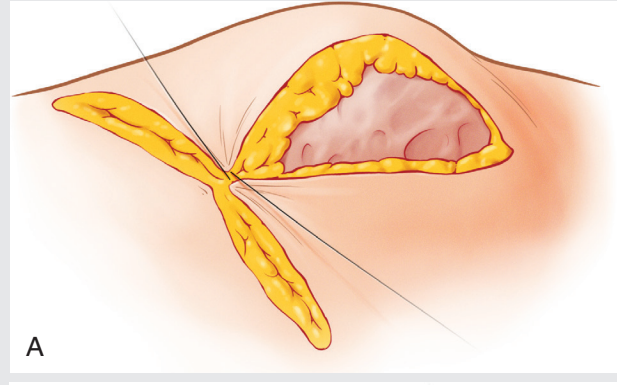


• Case 12.2.5

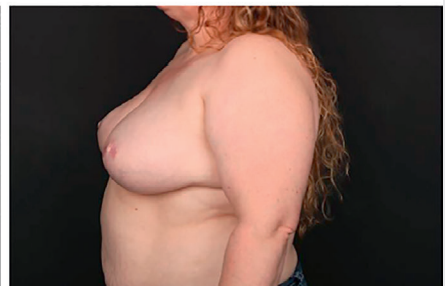
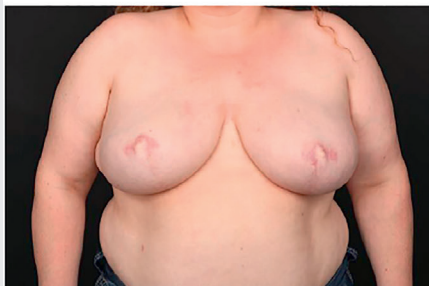
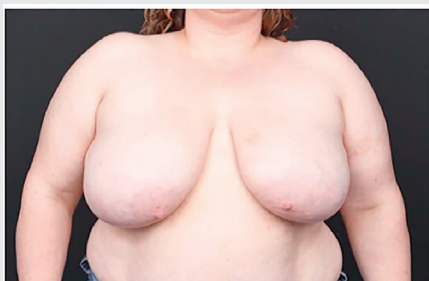
CASE 12.2—cont'd



• Case 12.2.6



• Case 12.2.7



• Case 12.2.8

(Case 12.2.8 reprinted with permission from Gabriel A, Maxwell GP. Prepectoral breast reconstruction in challenging patients. *Plast Reconstr Surg.* 2017;140(6S):14S–21S.)

CASE 12.3

Patient is a 53-year-old non-smoker with stage 1A invasive ductal carcinoma of the right breast. She has a BMI of 37 kg/m² and no history of hypertension, diabetes, or breast irradiation. She completed neoadjuvant chemotherapy prior to bilateral skin-sparing mastectomy. Immediate two-stage prepectoral reconstruction was performed after assessing for flap viability and vascularity intraoperatively. The need for adjuvant radiotherapy was known after first-stage

reconstruction. Tissue expansion was completed before irradiation of the expander (right breast). Six months after completion of radiotherapy, second-stage reconstruction with SRF 695 cc silicone implants was performed. One session of fat grafting was performed 3 months after second-stage reconstruction. [Case 12.3.1](#) shows the patient preoperatively (upper row) and 18 months after second-stage reconstruction (lower row).



• **Case 12.3.1**

([Case 12.3.1](#) reprinted with permission from Gabriel A, Maxwell GP. Prepectoral breast reconstruction in challenging patients. *Plast Reconstr Surg.* 2017;140(6S):14S–21S.)

Postoperative Care and Expected Outcomes

In the immediate postoperative period, a closed incision negative pressure therapy is applied to the incision to protect the incision from contamination. In patients who undergo nipple-sparing mastectomy, negative pressure therapy is also applied to the nipple–areola complex. Alternatively, Tegaderm (3M, St Paul, MN) followed by Dermabond (Ethicon US, LLC, Somerville, NJ) can be applied to the incision if negative pressure therapy is unavailable. The reconstructed breast is fitted with a soft compression bra to support and maintain the breast shape, prevent prosthesis migration, minimize the risk of shearing, and maximize adherence and integration of the acellular matrix. The compression bra is utilized for 4–6 weeks followed by transition to a comfort bra or sports bra.

Patients are typically discharged 1–2 days postoperatively and are followed up weekly to assess for signs and symptoms of seroma, tissue necrosis, and infection. Drains

are maintained until the output is less than 30 cc over a 24-hour period, which can take up to 1–2 weeks. In two-stage reconstructions, serial expansion is commenced after drain removal and is continued weekly until desired expansion is achieved, which typically takes about 1–2 months. In the case of air-filled expanders, the air is replaced with saline at the last expansion, typically during the third or fourth week of expansion.

Given the proximity of the prosthesis to the overlying skin, any trauma to the skin should be avoided, although thicker flaps are less sensitive to trauma than thinner flaps. Nonetheless, patients are advised to be cautious in the immediate postoperative period. Patients are advised to ambulate and move their upper extremities immediately after the surgery. They are referred to physical therapy, which they can commence after drain removal, but should not engage in strenuous activity for 6 weeks following the surgery. It should be noted that these are general guidelines and the ability to partake in physical activity may depend on the healing process or the extent of the oncological resection (i.e., axillary dissection).

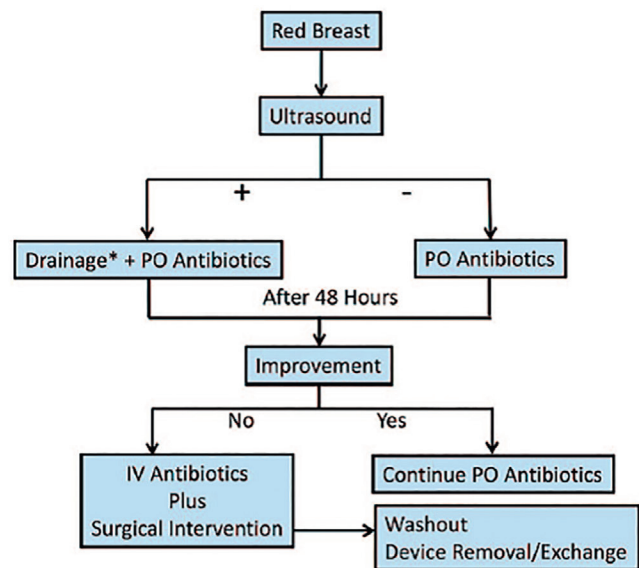
Management of Complications

In the immediate postoperative period, reconstructive surgeons need to be vigilant of complications, notably red breast and skin necrosis. The author advocates aggressive management at the first signs of these complications as under- or delayed management could potentially lead to prosthesis loss and reconstructive failure. The risk of prosthesis extrusion due to skin necrosis is elevated in the prepectoral approach compared with the subpectoral approach because of the relative lack of soft tissue coverage of the prosthesis in the former. Hence, it would be judicious to maintain a lower threshold for intervention in the prepectoral than one would normally do in the subpectoral approach.

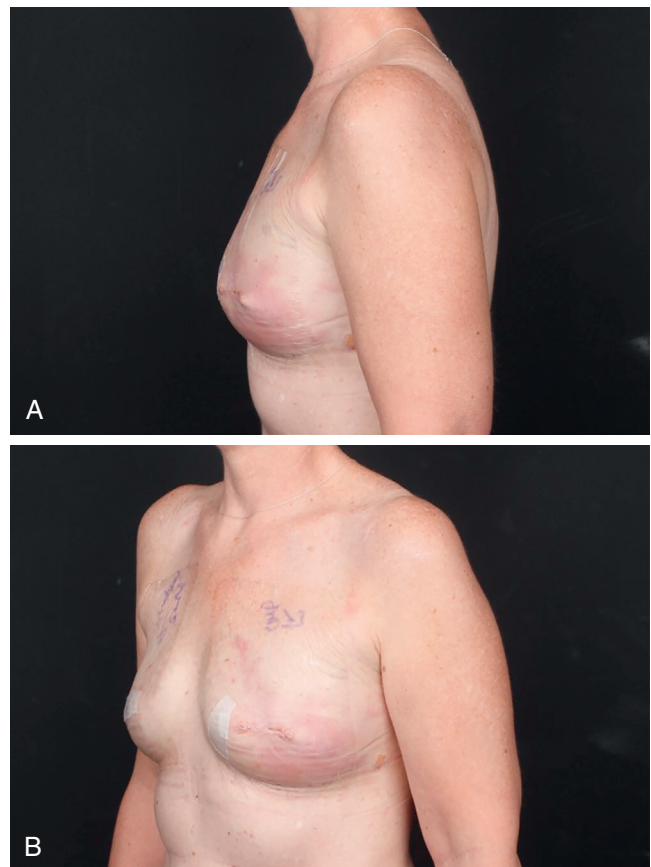
Signs of red breast (redness, erythema, and warmth; Fig. 12.1) may suggest underlying seroma or infection and are followed up with an ultrasound (Fig. 12.2). In the event of a positive ultrasound for seroma, it is drained immediately and oral antibiotics are administered. The patient is followed up after 48 hours to assess for improvement. If improvement is noted (see Fig. 12.2), oral antibiotics are continued. In the event of no improvement (Fig. 12.3), surgical intervention involving prosthesis removal (Fig. 12.4), pocket rinse with betadine solution, and placement of a new expander is undertaken, together with administration of broad-spectrum intravenous antibiotics until initial culture results are available. During prosthesis removal, the initial acellular matrix is also completely removed as it may be a source for biofilm formation. The new expander is placed prepecturally without acellular matrix coverage (“naked” expander; Fig. 12.5). The patient successfully recovered and underwent the second stage of her reconstruction (Figs. 12.6 & 12.7). The matrix is introduced during the second stage if the breast is salvaged. In the event of a negative ultrasound for seroma, oral antibiotics are administered and the patient is followed up after 48 hours. If signs/symptoms



• **Fig. 12.1** 52-year-old female with right breast cancer following bilateral skin-sparing mastectomy and immediate expander/ADM prepectoral reconstruction presenting on postoperative day 18 with erythema.



• **Fig. 12.2** Algorithm for the management of red breast. Asterisk, interventional radiology-guided drain placement; PO, oral; IV, intravenous. (Reprinted with permission from Sigalove S, Maxwell GP, Sigalove NM, et al. Prepectoral implant-based breast reconstruction: rationale, indications, and preliminary results. *Plast Reconstr Surg.* 2017;139(2):287–294.)



• **Fig. 12.3** (A,B) No improvement with antibiotics and small amount of fluid was aspirated with ultrasound on postoperative day 20.



• **Fig. 12.4** (A,B) Patient in the operating room for washout with more erythema on postoperative day 21.

improve, oral antibiotics are continued; if no improvement, then surgical intervention is undertaken with administration of intravenous antibiotics.

All degrees of skin necrosis are attended to with the same urgency. Minor and moderate skin necrosis is managed in the office. The necrosis is debrided and/or excised followed by a triple antibiotic rinse before closure. Severe necrosis is managed in the operating room with prosthesis removal, excision of necrotic tissue, antibiotic rinse of the pocket, and placement of a new prosthesis. Severe necrosis, however, is rarely encountered because of aggressive management of even mild necrosis.

Secondary Procedures

Fat grafting is the most commonly performed secondary procedure in prepectoral reconstructions. In fact, fat grafting is a critical adjunct procedure for successful outcomes in the prepectoral approach. Most patients who undergo prepectoral reconstruction will require fat grafting to enhance breast volume, contour, and/or shape as well as to mask implant visibility, rippling, and wrinkling at the upper pole. Even obese patients who have a thick subcutaneous layer may require fat grafting at the upper pole to prevent a step-off. Fat grafting also serves to facilitate gliding of the



• **Fig. 12.5** (A,B) Postoperative day 30 following removal of left expander and all ADM with placement of “naked” expander (without ADM) and now expanded.

subcutaneous pocket and improve the functionality of the reconstructed breast.

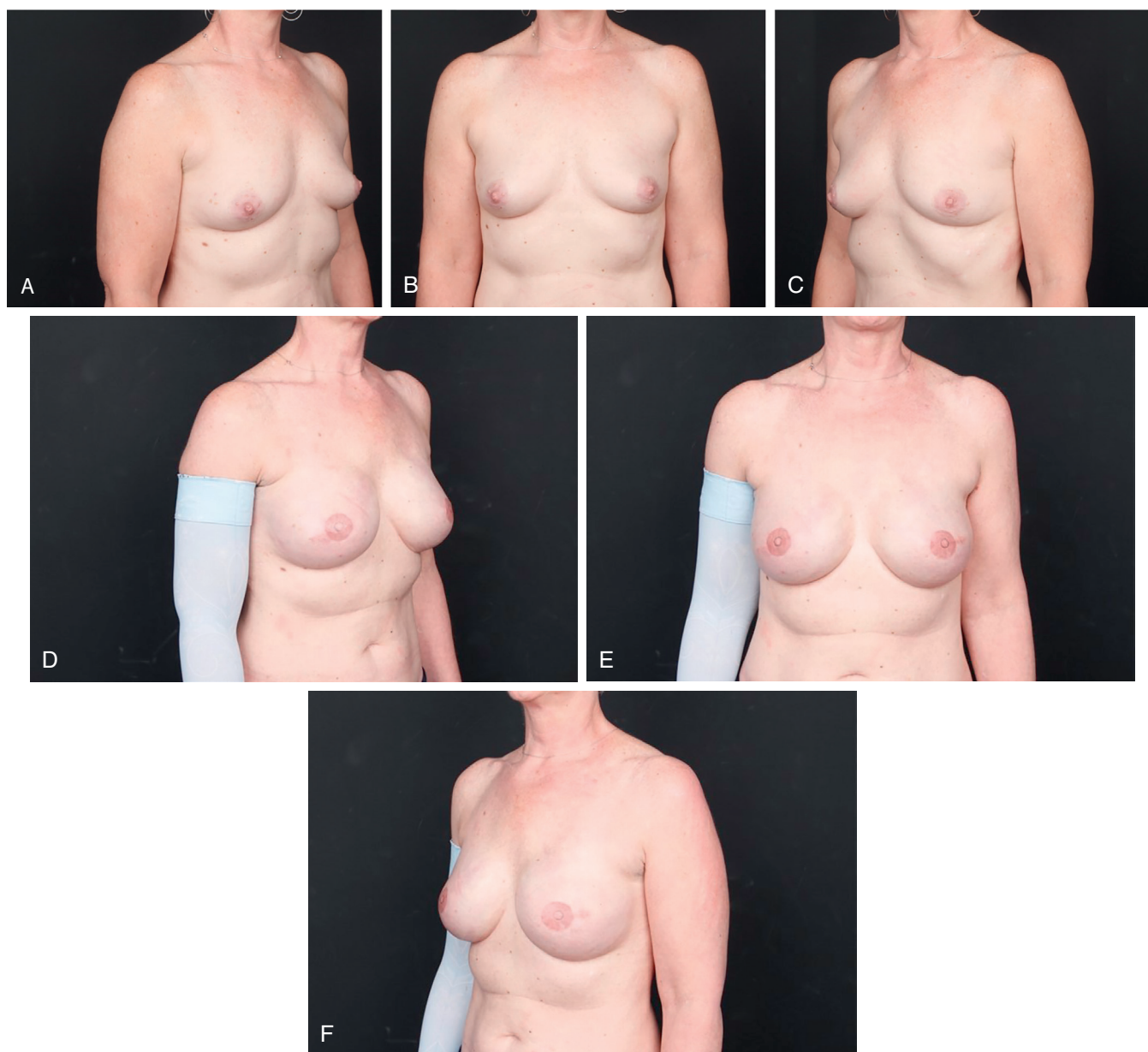
Fat grafting is typically performed as a third stage in two-stage reconstructions. At the second stage, pocket adjustments and capsulotomies, if performed, are allowed to heal and stabilize before fat grafting. A healed and stabilized environment allows for better fat retention and viability. In the event that no adjustments are made to the pocket at the second stage, fat grafting can be performed at this stage. In single-stage reconstructions, fat grafting is always performed at a second stage.

Conclusions

Prepectoral implant-based breast reconstruction simplifies breast reconstruction by obviating the need to dissect and elevate the pectoralis major muscle. In placing the implant over the muscle, the technique preserves the integrity of the pectoralis major muscle and eliminates the problems of muscle elevation, including pain, muscle spasm, animation deformity, and functional impairment of the muscle. The published literature attests to the feasibility and effectiveness of this technique. Careful patient selection and meticulous technique are, however, critical for successful outcomes.



• **Fig. 12.6** (A–C) Preoperative views and (D–F) 8 months following second stage with 410MX 520 cc implants.



• **Fig. 12.7** (A–C) Preoperative views and (D–F) 16 months following second stage with 410MX 520 cc implants. No fat grafting was performed in this case.

PEARLS FOR SUCCESS

- Patient selection is crucial for successful prepectoral reconstruction; oncological and reconstructive contraindications should be respected.
- Well-perfused, viable, mastectomy skin flaps are an absolute requirement for prepectoral reconstruction.
- Mastectomy flap perfusion should be assessed intraoperatively; if poorly perfused, reconstruction should be delayed.
- Prepectoral pocket collapse with advancement of subcutaneous tissue to lateral borders eliminates dead space and is critical in every reconstruction.
- Compression postoperatively with an appropriate bra ensures acellular dermal matrix incorporation.
- A very low threshold for operative intervention for skin necrosis and seroma is maintained.
- Fat grafting is a critical adjunct procedure that enhances breast aesthetics and helps mask implant visibility/rippling/wrinkling.

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13

Delayed Two-Stage Implant-Based Breast Reconstruction

PING SONG AND LEE L.Q. PU

Introduction

Implant-based breast reconstruction can also occur in a two-stage delayed approach after the primary mastectomy has been completed. Traditionally, delayed breast reconstruction often involves autologous tissue options due to the association with adjuvant radiation and the subsequent need for distant healthy tissue to recreate the breast.¹ However, the use of tissue expanders in a two-stage approach can also be performed safely with appropriate patient selection especially if the patient does not need postoperative radiation.²⁻⁵

Some women may choose to forego any decision for breast reconstruction prior to their oncologic surgery or may change their mind later. In these cases, the patient can be served with a two-stage total muscle coverage implant-based reconstruction.

In this chapter, the authors will describe tissue expander-based delayed breast reconstruction with total muscular coverage during the first-stage procedure. Emphasis will be placed on surgical technique, as well as highlighting key concepts in delayed implant-based breast reconstruction.

Indications and Contraindications

The delayed approach to two-stage implant-based breast reconstruction is indicated for patients who are, in general, good candidates for implant-based procedures.⁶ These include relatively thin patients and patients requiring bilateral reconstruction (Fig. 13.1). The success and outcome of delayed implant-based reconstruction depends less on a reliable native soft tissue envelope since, due to the delayed

nature of the reconstruction, the remaining mastectomy skin flaps have benefited from a delay phenomenon, making them more robust and reliable. Importantly, total muscular coverage relies on intact pectoralis major and serratus muscles as part of the reconstruction.

Furthermore, delayed reconstruction can serve a valuable role if immediate reconstruction is threatened by compromised mastectomy flaps, which risk prosthesis exposure or extrusion. If an autologous option is not possible, then a delayed two-stage implant-based reconstruction can be performed if the patient desires implant-based reconstruction.

On the contrary, relative contraindications to implant-based reconstruction include severe radiation changes or poor native skin for coverage of the implant. Other relative contraindications include obesity, smoking, and poorly controlled medical co-morbidities such as diabetes. Additionally, the senior author does not proceed with delayed implant-based reconstruction if the pectoralis major muscle has been resected or significantly traumatized. In cases of radiation or damaged pectoralis muscle, the senior author prefers a pedicled latissimus dorsi myocutaneous flap with a tissue expander for the two-stage delayed breast reconstruction.

Preoperative Evaluation and Special Considerations

A thorough discussion should be had with the patient prior to undergoing delayed implant-based breast reconstruction. A careful physical exam must also be performed, and key factors highlighted, such as missing pectoralis major muscle or serratus anterior muscle, quality of overlying skin, and potential regional coverage options such as the latissimus dorsi muscle (Fig. 13.2). Expectations must also be addressed, including initial or final breast shape and size. Patients should be counseled that delayed reconstruction in the setting of limited skin pliability can lead to a slower or

Disclosure: The authors have no financial interest to declare in relation to the drugs, devices, and products mentioned in this article.



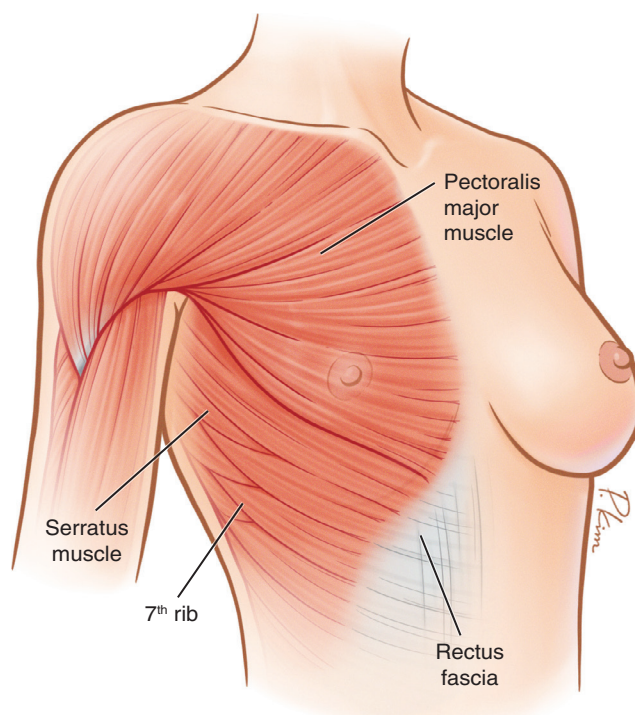
• **Fig. 13.1** A good candidate for delayed two-stage implant-based breast reconstruction. In general, the patient should have intact pectoralis major and serratus anterior muscles in the anterior chest wall and no significant radiation damage to the remaining breast skin.



• **Fig. 13.2** A typical patient has a missing portion of the pectoralis major muscle in her right anterior chest wall and significant radiation damage to the remaining breast skin. In this patient, a latissimus dorsi flap should be used to replace the radiated breast skin and missing portion of the pectoralis major muscle for an implant-based breast reconstruction.

difficult expansion process as well as result in a less natural shape of reconstructed breast, especially lack of a well-defined inframammary fold.

Regarding the expansion process, attention is paid to the lower pole. Specifically, it will be important to choose a tissue expander that can preferentially expand the lower pole more. Surgical planning will also assist in redefining a new inframammary fold that is at the appropriate location. When using traditional tissue expanders, the placement of the tissue expander must be lower than the actual level of the inframammary fold in reference to the contralateral side so that the expansion for the lower pole can be optimized.



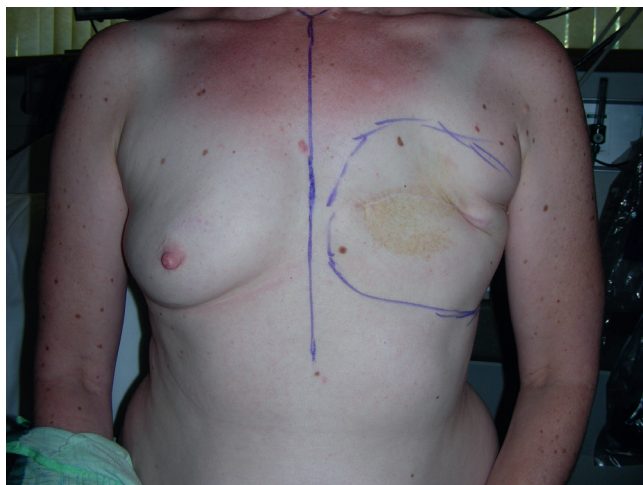
• **Fig. 13.3** A schematic diagram shows the anatomy of complete submuscular coverage for a tissue expander by a created pocket of the pectoralis major and serratus anterior muscles with or without the portion of the anterior rectus fascia.

It is also important to emphasize need for total muscular coverage of the implant. In this manner, the pectoralis major muscle, serratus anterior muscle, as well as fascia of the rectus abdominis should be present. This will ensure that in cases of skin breakdown no implant is directly exposed. However, this also poses a risk for high-riding implants from the forces exerted by the overlying muscles. Patients must be informed of these risks as well as the post-operative discomfort and soreness that will result from the above-noted dissection.

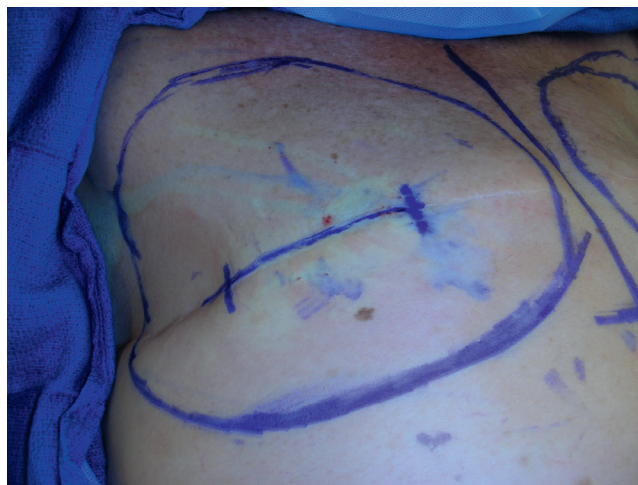
Surgical Techniques

Relevant Surgical Anatomy

Total muscular coverage requires dissection to raise the pectoralis major muscle as well as the adjacent serratus anterior and the rectus abdominis fascia (Fig. 13.3). The pectoralis major muscle has origins from the medial half of the clavicle, the sternum, the costal cartilage from the first to sixth ribs, and from the aponeurosis of the external oblique muscles. The fibers insert into the bicipital groove of the humerus. The blood supply is from the thoracoacromial artery which lies on the deep surface of the muscle. The serratus anterior muscle originates from the first through eighth ribs and has multiple slips that insert into the medial



• **Fig. 13.4** A standard preoperative marking for the left delayed two-stage implant-based breast reconstruction.



• **Fig. 13.5** Intraoperative view shows an outline of the new breast pocket for placement of a tissue expander and the planned skin incision.

edge of the scapula. The rectus abdominis fascia lays inferior to the pectoralis muscle. The fascia can be dissected off the muscle belly in order to provide inferior implant coverage.

Preoperative Markings

On the morning of surgery, the patient is seen and marked in the standing position. The anatomic landmarks include the sternal notch, midline, and proposed new inframammary fold and lateral border of the breast as well as the breast “footprint” (Fig. 13.4). Specific attention must be paid to the placement of the new inframammary fold as intraoperative dissection and subsequent expansion relies on the proper recreation of the fold. Several options of expanders are available, but the final decision is made by the plastic surgeon intraoperatively after the new breast total muscle pocket is created. This ensures that each patient receives a reconstruction tailored to her individual needs.

Intraoperative Markings

The borders of the breast as well as its “footprint” will be transposed inside on top of the chest wall and muscles to help recreate the implant pocket. The two key areas are the inframammary fold and anterior axillary line, as this will require dissection of the serratus anterior muscle and rectus fascia in order to define the fold and lateral extent of the new breast. The transposed markings will also serve to guide muscle elevation and submuscular pocket dissection.

Details of the Procedure

The surgical exposure for delayed implant-based reconstruction is created through the prior well-healed mastectomy scar. However, only a portion of the original incision may



• **Fig. 13.6** Intraoperative view shows the elevation of the skin flap and created skin pocket.

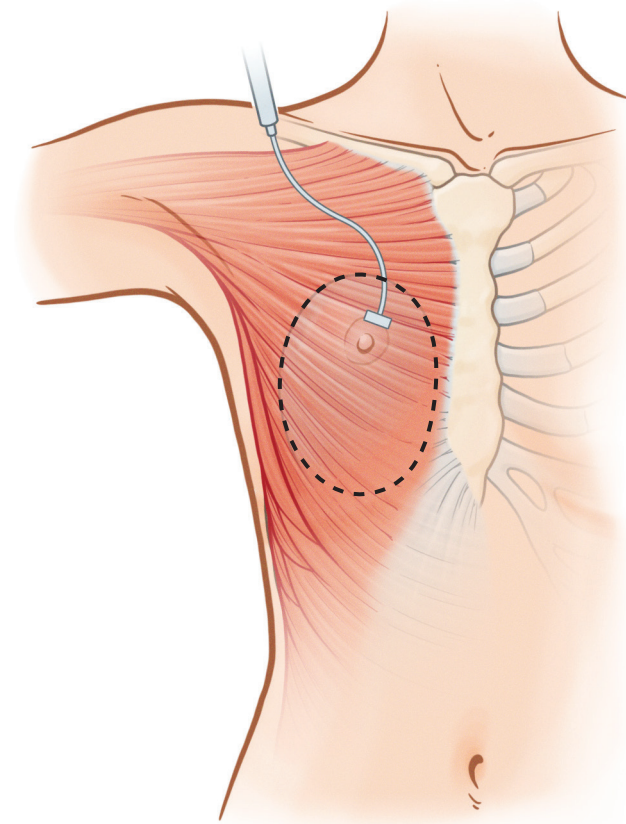
be used during the reconstruction (Fig. 13.5). Prior to incision, the incision is infiltrated with 1% lidocaine with epinephrine. The procedure begins by making the incision through the skin and subcutaneous tissue down to the prepectoral fascia. Using sharp dissection and lighted retractor, the skin flaps are elevated to the borders of the pre-marked breast border to create the soft tissue envelope (Fig. 13.6). Next, the lateral border of the pectoralis major muscle is identified and from here, the muscle is raised. Again, be sure to achieve adequate hemostasis from any perforating vessels during this dissection. Care must be taken with dissection underneath the pectoralis major muscle to avoid injury to the thoracoacromial artery. It is also wise to avoid cautery dissection directly on top of the ribs, as this will lead to increased postoperative pain.

Attention is then turned to the anterior rectus abdominis fascial sheath, which is elevated from the muscle belly. Take this dissection inferiorly and as low as possible using the proposed pre-marked inframammary fold as guide. Remember, the expander is ideally placed 1–2 cm below the inframammary fold to allow for maximal expansion in the lower pole of the breast. Next, the serratus anterior muscle is identified and dissected from the chest wall from anterior to posterior along the chest wall. This dissection defines the lateral extent of the submuscular pocket.

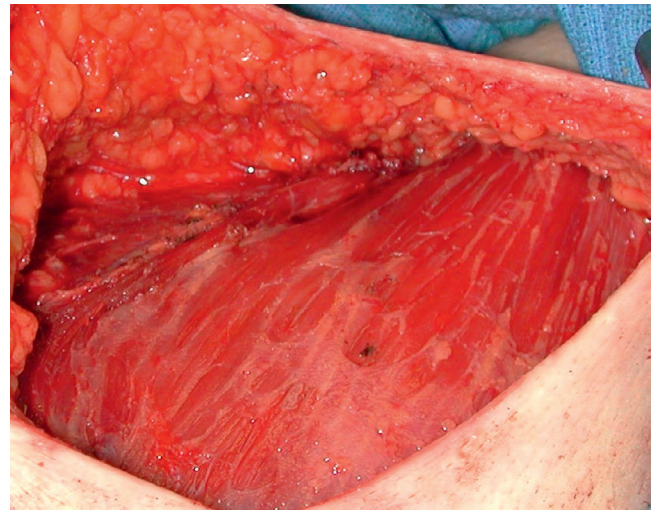
The pocket is then irrigated thoroughly with triple antibiotic solution in the standard fashion. The appropriate size of a medial high tissue expander is selected and placed within the submuscular pocket with a no-touch technique. The expander should be placed as low and medial as possible (Fig. 13.7). Closure of the muscular pocket is taken by suturing the anterior border of the serratus anterior to the lateral border of the pectoralis muscle with 3-0 Vicryl sutures in an interrupted figure-of-eight fashion (Fig. 13.8). Intraoperative fill volume of methylene blue injectable saline depends on clinical assessment of the skin envelope and muscle pocket. The initial volume can be between 60 and 180 cc. Of note, this is less than in the case of

immediate reconstruction due to constraints from the tighter soft tissue envelope. The goal is to decrease dead space while maintaining healthy skin flap perfusion to avoid skin flap necrosis.

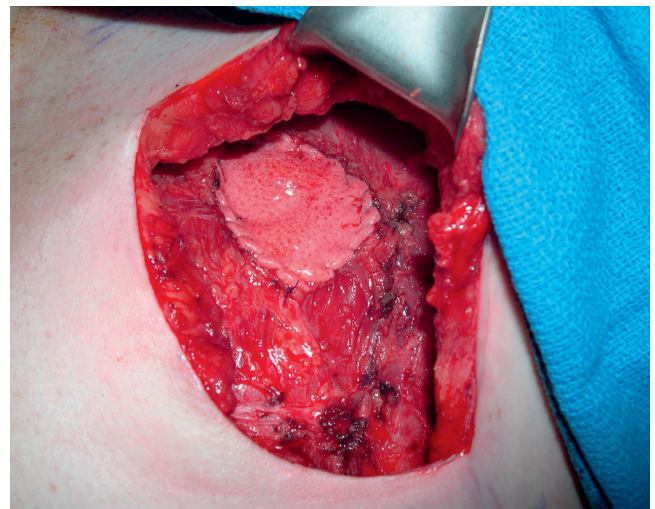
If the muscular pocket cannot be closed completely, a small piece of acellular dermal matrix can be used to cover the implant at the inferior position (Fig. 13.9). Finally, one drain is inserted into the breast skin pocket and secured at the exit site. The rest of the incision is closed in two layers. For all our breast cases, the incision is covered with Steri-Strips and fluff gauze and supported with a soft surgical bra.



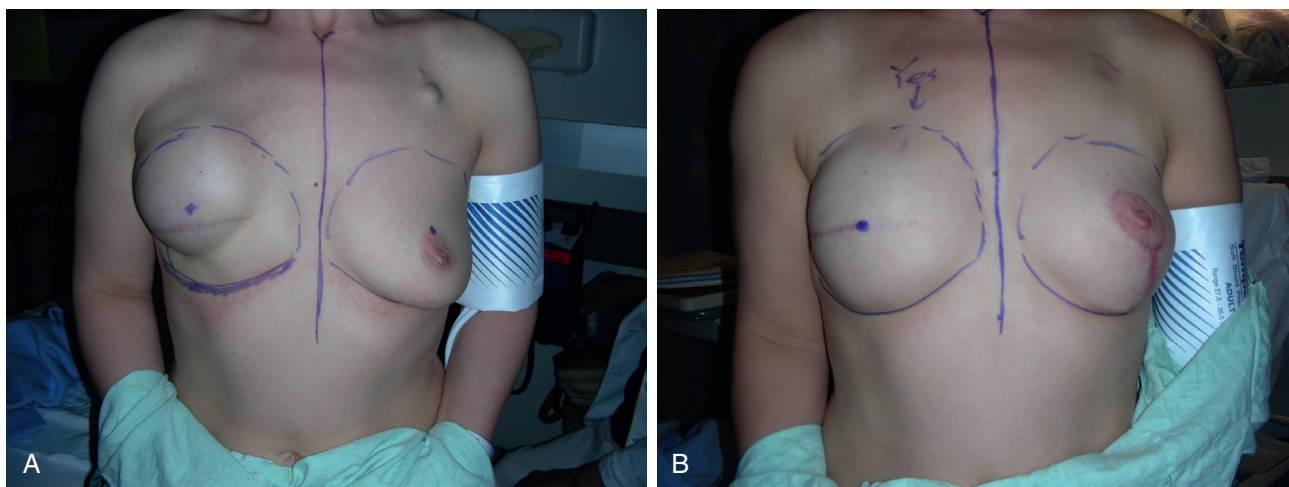
• **Fig. 13.7** A schematic diagram shows the complete submuscular coverage of a tissue expander with initial minimal expansion by the pectoralis major and serratus anterior muscles.



• **Fig. 13.8** Intraoperative view shows the complete submuscular coverage of a tissue expander. Both elevated pectoralis major and serratus anterior muscles are approximated with sutures.



• **Fig. 13.9** Intraoperative view shows a piece of acellular dermal matrix can be added to the lower portion of the pectoralis major muscle where there is no adequate muscle for a complete coverage of such a pocket.



• **Fig. 13.10** (A) A typical “high-ride” placement of a tissue expander after delayed first-stage tissue expander breast reconstruction. (B) Correction of this condition by lowering new implant placement via capsulotomy and recreation of new inframammary fold.

Postoperative Care and Expected Outcomes

All patients are discharged home with soft surgical bra and a short course of oral antibiotics. Drains are removed once output decreases to less than 30 cc a day.

In the absence of delayed wound healing from the incisions, we routinely begin expansion at three weeks. Patients undergo, on average, 120 cc of fill each clinic visit every three weeks until we reach 20%–25% overexpansion. Patients do not require adjuvant treatment modalities due to the delayed nature of the reconstruction.

It is relatively common that the patient may have initial “high ride” breast tissue expander when a total muscular coverage is done. However, this condition can be corrected somehow during the second stage reconstruction when the new inframammary fold can be lowered further and then reconstructed. Subsequent tissue expansion should be adjusted according to skin flap pliability and aggressive compression to the underlying ribs should be avoided for “greater” expansion.

Case Examples

CASE 13.1

A 32-year-old white woman had previous left mastectomy for breast cancer about 2 years ago and desired implant-based breast reconstruction (Case 13.1.1). She had completion of tissue expansion after successful placement of a tissue expander (450 cc) with initial filling of 60 cc (Case 13.1.2). She underwent the second-stage reconstruction with tissue expander/implant exchange. During the procedure, inferior capsulotomy and reconstruction of a new inframammary fold

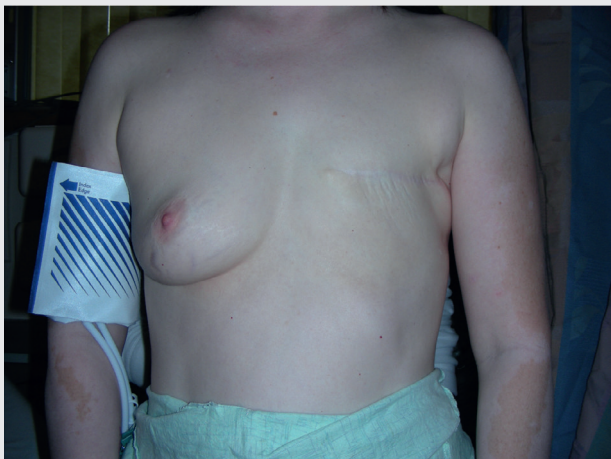
Second-Stage Reconstruction

The second-stage reconstruction involving tissue expander to implant exchange occurs two to three months after the first stage. Through the initial incision, but limiting the length, careful dissection is carried down through the muscle layer. The expander is deflated via puncture and aspiration with suction. After removal of the expander, capsulotomy is usually needed medially and inferiorly for further adjustment of the muscle pocket. High-ride implant replacement can be corrected during this operation by lowering the pocket aggressively and reconstructing the new inframammary fold using 2-0 or 3-0 PDS suture. In addition, scoring the capsule in the lower part of the muscle pocket can also improve proper placement of the implant (Fig. 13.10). The pocket is thoroughly irrigated with triple antibiotics and the new permanent implant is placed via Keller funnel. A high-profile, smooth, round silicone implant is routinely selected to replace the tissue expander in the senior author's practice for the second-stage implant-based breast reconstruction. The incision is then closed in three layers.

as well as capsulorrhaphy were performed before placement of a permanent silicone breast implant (300 cc). She also had right vertical mastopexy as a symmetry procedure at the same time. She subsequently had left nipple–areola complex reconstruction. Her entire postoperative course was uneventful. Results are shown 12 months after nipple reconstruction and 18 months after initial breast reconstruction (Case 13.1.3).

Continued

CASE 13.1—cont'd



• Case 13.1.1



• Case 13.1.2



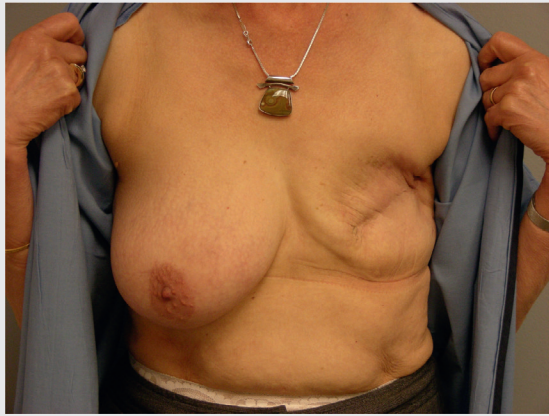
• Case 13.1.3

CASE 13.2

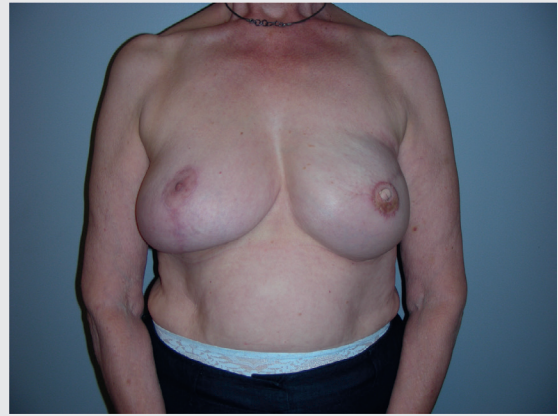
A 69-year-old white woman had previous left mastectomy for breast cancer more than 10 years ago and had decided to proceed with implant-based breast reconstruction ([Case 13.2.1](#)). She had completion of tissue expansion after successful placement of a tissue expander (400 cc) with initial filling of 60 cc ([Case 13.2.2](#)). She underwent the second-stage reconstruction with tissue expander/implant exchange. During the procedure, inferior capsulotomy and reconstruction of a new inframammary fold were performed before placement of a permanent silicone breast implant (500 cc). She also had right small breast reduction as a symmetry procedure at the same time. She subsequently had left nipple-areola complex reconstruction. Her entire postoperative course was uneventful. Results are shown 8 months after nipple reconstruction and 17 months after initial breast reconstruction ([Case 13.2.3](#)). Additional follow-up results are shown 13 months after nipple reconstruction and 24 months after initial breast reconstruction ([Case 13.2.4](#)).



• Case 13.2.2



• Case 13.2.1



• Case 13.2.3



• Case 13.2.4

CASE 13.3

A 59-year-old white woman had previous left mastectomy for breast cancer more than 5 years ago and had decided to proceed with implant-based breast reconstruction (Case 13.3.1). She had completion of tissue expansion after successful placement of a tissue expander (450 cc) with initial filling of 120 cc. She underwent the second-stage reconstruction with tissue expander/implant exchange. During the procedure, inferior capsulotomy and reconstruction of a new inframammary fold were performed before placement of a

permanent silicone breast implant (425 cc). She also had right inverted T mastopexy as a symmetry procedure at the same time. She subsequently had left nipple–areola complex reconstruction. Her entire postoperative course was uneventful. Results are shown 4 weeks after nipple reconstruction and 12 months after initial breast reconstruction (Case 13.3.2). Additional follow-up results are shown 3 months after nipple reconstruction and 15 months after initial breast reconstruction (Case 13.3.3).



• Case 13.3.1



• Case 13.3.2



• Case 13.3.3

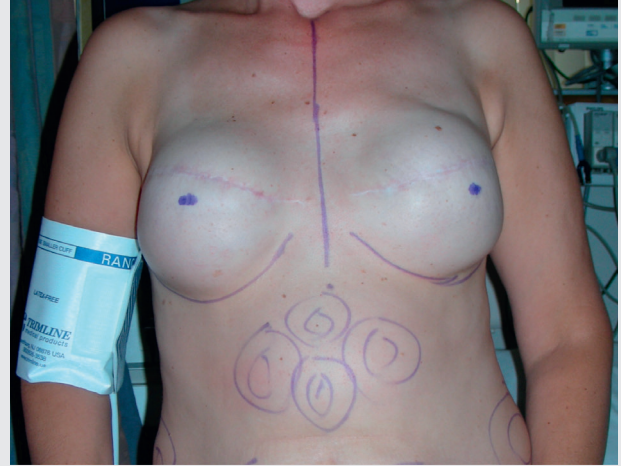
CASE 13.4

A 45-year-old white woman had previous bilateral mastectomies for left breast cancer about 9 months ago and had decided to proceed with bilateral implant-based breast reconstructions (Case 13.4.1). She had completion of tissue expansion after successful placement of a tissue expander (400 cc) with initial filling of 60 cc (Case 13.4.2). She underwent the second-stage reconstruction with tissue expander/implant exchange. During the procedure, inferior capsulotomy and reconstruction of a new inframammary fold

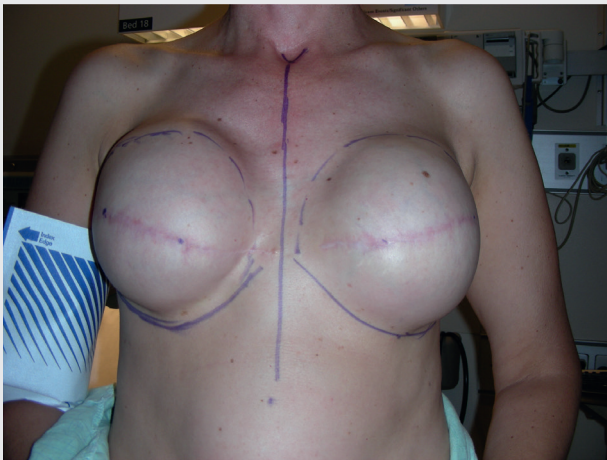
were performed before placement of a permanent silicone breast implant (375 cc) (Case 13.4.3). She subsequently had nipple-areola complex reconstruction on both sides and during that procedure, abdominal liposuction was also performed for cosmetic reasons (Case 13.4.4). Her entire postoperative course was uneventful. Results are shown 22 months (Case 13.4.5) and 25 months (Case 13.4.6) after initial breast reconstruction.



• Case 13.4.1



• Case 13.4.4



• Case 13.4.2



• Case 13.4.5



• Case 13.4.3



• Case 13.4.6



• **Fig. 13.11** Intraoperative view shows a very tight muscle pocket on the left side due to previous radiation. In this patient, even the initial placement of a tissue expander was successful but subsequent expansion was not likely to be successful. A latissimus dorsi flap was eventually used for subsequent breast reconstruction to replace radiated skin on this side.

Management of Complications

In the senior author's experience, the majority of postoperative complications are seen in cases of delayed breast reconstruction after adjuvant radiation therapy. The radiation breast skin damage predisposes these patients to slower healing or incision breakdown and also creates a tighter skin envelope for expansion even after the incision has healed properly (Fig. 13.11).

Other complications from two-stage prosthetic breast reconstruction include hematoma or seroma, infection, and implant exposure. All above complications can be managed accordingly. However, implant exposure should be managed by initial implant removal and subsequent reconstruction with a latissimus dorsi flap.⁷ A tissue expander or implant can be inserted at the same time or during a secondary procedure.

Secondary Procedures

After the second-stage implant-based breast reconstruction, patients may present with several problems related to shape, size, contour, and even symmetry of their reconstructed breasts. Implant malposition is relatively common compared with immediate reconstruction and can be managed with repositioning of the "old" breast implant after adjustment of the muscle pocket and inframammary fold position. A smaller size of reconstructed breast can be improved by an implant exchange with a larger size or different shape. Contour depression in the upper pole of the reconstructed breast can be treated with a series of fat grafting procedures. Excess skin or tissue over or around the reconstructed breast can be treated with direct excision or liposuction. Composite breast reconstruction can be done by adding fat to an

implant-based reconstructed breast to significantly improve reconstructed breasts in selected patients.⁸

Conclusion

Delayed two-stage implant-based breast reconstruction is a supplementary technique to every plastic surgeon who performs immediate reconstruction. The delayed approach gives the reconstructive surgeon the ability to optimize timing in cases of threatened mastectomy flaps in the immediate setting. It also serves as an option for patients who choose reconstruction after their oncologic treatment is complete. However, a less optimal reconstructive outcome is common after the delayed breast reconstruction and more revision surgeries are needed in order to achieve a more acceptable result. In addition, postoperative radiation damage to the remaining breast skin presents a potential threat to the success of such a reconstruction.

PEARLS FOR SUCCESS

- Appropriate patient selection for implant-based reconstruction.
- Preoperative counseling regarding postoperative course, including setting realistic expectations and potential revision procedures.
- Preoperative markings to ensure new inframammary fold is "lower" enough to prevent high-ride placement of tissue expander and to ensure lower pole expansion.
- Attention to raising healthy and adequate skin flaps during skin envelope dissection and to ensure total muscular coverage.
- Initial intraoperative fill of the tissue expander should allow for a "hand-in-glove" fit within the new breast pocket and skin envelope.
- Subsequent tissue expansion should be adjusted according to skin flap pliability and aggressive compression to the underlying ribs should be avoided for greater expansion.
- IMF reconstruction and capsular scoring are essential procedures to ensure adequate lower pole contour and proper implant placement.
- Additional subsequent revisions are common and necessary to achieve an optimal outcome.

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14

Implant Breast Reconstruction – Revision

ARA A. SALIBIAN, JORDAN D. FREY AND NOLAN S. KARP

Introduction

Rates of breast reconstruction after mastectomy are increasing and have been paralleled by a rise in implant-based reconstruction.¹ Single-stage immediate implant placement and two-stage tissue-expander techniques have demonstrated good safety profiles² and patient satisfaction with outcomes.³ Advances in total submuscular and dual-plane reconstruction with acellular dermal matrix (ADM) or mesh as well as more recent prepectoral placement of implants have allowed for low complication rates with reproducible outcomes.^{4,5} However, despite optimization of these techniques, patients will often require revision of their reconstructions.

Over the long term, rates of revision for implant-based breast reconstruction can be significant, with risk of reoperation over a nine- to ten-year period ranging from 47.9% to 54.6% in large multicenter core silicone implant trials.^{6,7} While these include sequelae of acute infectious and ischemic complications, the majority of cases are secondary to more chronic processes. Tertiary revision rates are additionally high, with risk of reoperation near 50%.^{6,7} Single-stage reconstructions have decreased the number of reconstructive procedures after mastectomy. However, immediate implant reconstructions still require an average of 1.3 procedures per breast in our experience⁸ with revision rates of around 21% described in the literature.⁹

Several techniques are available to the plastic surgeon to address secondary aesthetic and functional complications that necessitate revision of breast reconstruction. These techniques along with their respective indications for subacute and long-term revision of implant-based breast reconstruction will be reviewed in this chapter. Other common revision procedures such as fat grafting as well as correction of nipple–areola complex (NAC) malposition are discussed elsewhere in this textbook.

Indications and Contraindications

There is a broad spectrum of indications for several different secondary revision procedures in implant-based breast reconstruction (Table 14.1). Adjustment of the inframammary fold (IMF) is indicated for correction of vertical implant malposition. Failure to secure the IMF to the chest wall if intentionally disrupted can result in inferior migration of the implant and a “bottoming out” phenomenon. Setting the fold too high, or inadequate dissection of the pocket inferiorly, can result in a high-riding implant. If the fold is intentionally lowered, but attachments of the native IMF to the pectoralis major are not completely obliterated, a second transverse band can become apparent, similar to a milder form of the double-bubble deformity in breast augmentation.

Pocket adjustments include capsulorrhaphy to tighten various aspects of the capsule, capsulotomy or scoring of the capsule to allow for release in a particular direction, and even capsulectomy, or removal of portions of the capsule. Indications for capsular modifications include medial and lateral implant malposition in addition to vertical malposition causing asymmetry. Lateral migration of the implant may occur due to excess lateral dissection of the pocket as well as a size mismatch between the implant and the implant pocket. Similarly, medial migration due to overdissection over the sternum will result in symmastia and requires lateralization of the implant. Malposition of the NAC can also be corrected with capsular procedures if NAC displacement is secondary to an underlying capsular deformity.¹⁰

Asymmetry in breast size can be addressed with implant exchange to either larger or smaller implants, in conjunction with capsular modifications as needed. Baker grade III/IV capsular contracture also necessitates removal of implants and replacement if desired. Reported rates of capsular contracture in primary reconstructions have traditionally been around 14%,^{6,7} though these have decreased significantly

TABLE 14.1 Indications for Revision of Implant-Based Reconstruction*

Indication	Procedures
Implant malposition	IMF repositioning Capsulorrhaphy Capsulotomy/capsulectomy ADM/mesh reinforcement
Size asymmetry	Implant exchange Fat grafting
Capsular contracture	Capsulectomy Implant exchange Pocket change to submuscular ADM
Animation deformity	Pocket change to prepectoral
Rippling	Implant exchange Pocket change to submuscular ADM/mesh support

*Indications for nipple–areola complex repositioning and fat grafting described elsewhere in this textbook. IMF, inframammary fold; ADM, acellular dermal matrix.

with utilization of acellular dermal matrix in certain series.¹¹ Regardless, severe capsular contracture requires aggressive treatment with capsulectomy and implant exchange as well as possible pocket change and utilization of adjunctive biomaterials in appropriate scenarios. Other indications for change of the implant pocket include animation deformity with pocket change to a subcutaneous plane.¹² On the other hand, complications more common in the subcutaneous plane, such as overlying breast rippling due to a lack of soft tissue coverage, can be treated with pocket change to the submuscular plane or change to a more cohesive implant.

Acellular dermal matrix (ADM) and mesh have recently emerged as a tool for treating several common complications after implant-based breast reconstruction.¹³ Acellular dermal matrix and/or mesh can be used for inferior support and definition of a new or pre-existing IMF when performing adjustment of the fold in cases of vertical malposition including high-riding and bottomed-out implants. ADM can also be utilized as an adjunct treatment for severe capsular contracture. Similar to the concept of submuscular pocket change in rippling, ADM can also serve to provide additional overlying soft tissue coverage in cases of rippling due to deficiencies in soft tissue.

Each planned revision procedure must be considered with regards to its efficacy in solving the presenting problem as well as in the overall clinical care of the patient. The integrity of the reconstruction and risk for compromising a reconstruction must be considered in each case. Any planned revisions during a patient's oncologic treatment should be coordinated with the patient's oncologic surgeon and oncologist. Lastly, patients must be counseled on realistic expectations and revisions should not be undertaken solely to

please the patient or the surgeon if there are no defined and attainable goals.

Preoperative Evaluation

A thorough understanding of all the relevant factors of the preceding procedures is critical in preparing for a successful revision. If a patient has undergone nipple-sparing mastectomy, great care must be taken to prevent nipple–areola complex ischemia and maintain appropriate nipple position during revision surgery. The plane of prior implant placement is relevant in assessing implant malposition and the need for pocket exchange. Furthermore, prior expansion versus immediate implant placement can affect pliability of the skin envelope in accommodating changes in implant size.

The patient's postoperative course after initial reconstruction is important to consider with regards to implications for secondary revisions. Postoperative hematoma has been associated with an increased risk of capsular contracture. Ischemic complications of mastectomy flaps can compromise the availability of skin and soft tissue if full-thickness necrosis requires excision. Adjuvant therapies such as chemotherapy can also influence complication rates.¹⁴ Patients that have undergone or are planned to receive radiation treatment must be approached with caution due to contracture of the skin envelope, fibrosis and impaired perfusion of the soft tissues.

Breast asymmetry should be analyzed and addressed in a methodical fashion. Discrepancies in breast size are analyzed to determine whether apparent asymmetry is secondary to implant size, chest wall deformity, implant positioning, and/or the overlying soft tissue envelope. Next, implant malposition is similarly analyzed in a stepwise fashion, first in the vertical and then the horizontal vectors (Table 14.2). In cases of inferior malposition, the relation of the implant to the IMF and distance of the inferior pole of the implant from the IMF is noted. In cases of superior malposition, it should be determined if the IMF was incorrectly set too high, if contracture of the soft tissue envelope and capsule is contributing, or if the high-riding implant is secondary to a combination of these factors.

Malposition in the horizontal vector is analyzed with consideration of either over- or under-dissection of the implant pocket, as well as the congruity of the pocket with implant size and the overlying skin envelope. Medial over-dissection, especially with dissection beyond the borders of the breast and over the sternum during mastectomy, can result in symmastia. Lateralization of the implant can also occur with overdissection, particularly with a discrepancy between a larger soft tissue envelope and the implant, when the implant can “fall” laterally. The appropriate pocket adjustments should be planned in concert with evaluation of the skin envelope to determine ease of repositioning and natural redraping of the skin.

When assessing implant malposition and planning corrective procedures, it is critical to take into account the

TABLE 14.2 Important Factors in Assessment of Implant Malposition

Skin	Quality and elasticity of skin envelope Excess or deficient skin in relation to implant size Scars Radiation changes NAC position
Soft tissue & capsule	Location of native IMF Integrity of IMF Presence of remnant native IMF if fold relocated Quality of capsule & presence of contracture Medial and lateral extents of implant pocket
Implant	Implant size Anatomic versus round implant Plane of implant placement Use of acellular dermal matrix or mesh

NAC, nipple–areola complex; IMF, inframammary fold.

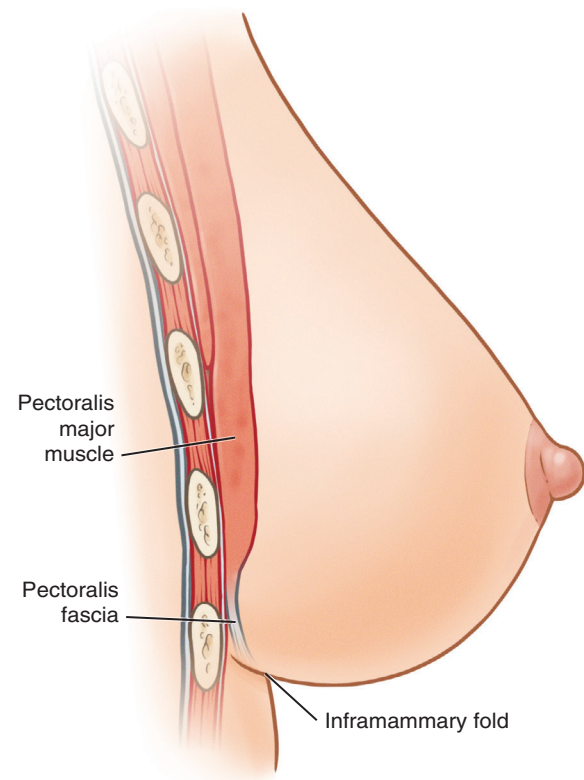
position of the nipple–areola complex. Standard measurements including nipple to sternal notch distance and nipple to inframammary fold distance should be taken again. It must be determined if manipulation of the underlying implant and capsule will affect nipple position favorably or unfavorably. In these cases, additional manipulation of the nipple with mastopexy or directional techniques may be required,¹⁰ and must be planned in advance to avoid nipple malposition after revision procedures.

Capsular contracture should be graded according to severity¹⁵ and also evaluated with regards to the particular cosmetic deformation of the breast in relation to the natural anatomic breast. Rippling should be analyzed with regards to the size of the implant placed, the implant pocket and the quality of the overlying skin. In patients presenting with animation deformity of the breast, the severity of the deformity should be assessed, particularly with regards to its impact on the patient's lifestyle.

Surgical Techniques

Relevant Surgical Anatomy

The anatomical borders of the breast include the sternum medially, the clavicle superiorly, the lateral border of the pectoralis muscle laterally and the IMF inferiorly. As described, the IMF is particularly important as an aesthetic landmark that defines the reconstructed breast. The fold consists of fascial attachments from the pectoralis major fascia to the dermis of the breast (Fig. 14.1) that must be reconstructed if violated, or obliterated if moving the IMF. Medial perforating vessels arising off of the internal mammary artery and



• **Fig. 14.1** Anatomy of the inframammary fold. The inframammary fold is composed of fascial attachments from the pectoralis fascia at its inferior insertion to the dermis. It is a key structure in the overall aesthetic appearance of the breast and must be reconstructed accordingly. Vertical implant malposition is intricately related to the inframammary fold, correction of which involves resetting the fold at the appropriate position through a variety of techniques. (Adapted from Handel, N. The double-bubble deformity: cause, prevention, and treatment. *Plast Reconstr Surg.* 2013;132(6):1434–1443, Figure 2.)

traversing the interspaces just lateral to the sternum are also important to preserve to maximize perfusion to the breast skin envelope.

Preoperative Markings

The patient is initially marked preoperatively in the standing position. The midline is marked from the sternal notch to the xiphoid process. The inframammary folds are then marked bilaterally as well as the superior breast border and lateral definition of the breast to visualize the breast footprint. If the IMF needs to be adjusted, the planned new position of the IMF is marked for reference. In cases of implant malposition, areas on the breast where the pocket will be expanded and capsulotomy will be performed are outlined so that markings reflect final desired implant position. All markings are confirmed in the operating room prior to starting the case and any adjustments are made accordingly.

Surgical Exposure

The patient is placed on the operating room table in the supine position and both arms are abducted at 90 degrees

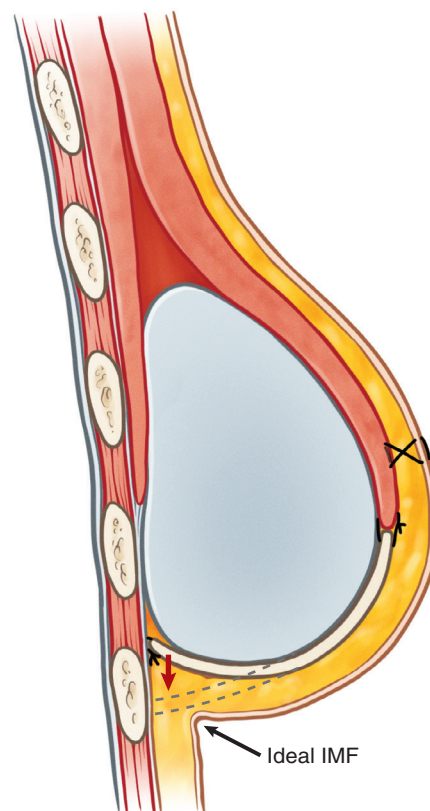
and secured to arm boards. A dilute lidocaine and epinephrine solution is infiltrated under the incisions to allow for a bloodless dissection, minimize intraoperative anesthesia requirements and decrease postoperative pain. The incision is carried down to the capsule which is then incised to gain access to the implant pocket at a level staggered from the skin incision. At this time, the entirety of the pocket is surveyed for any suspicious lesions which, if present, are excised and sent for surgical pathology. The implant can be protected with a retractor if a focal area is being revised. However, if limiting access or visualization, the implant is removed and immediately placed in a covered container with triple antibiotic solution (80 g gentamicin, 50 000 units of bacitracin and 1 g cefazolin in 500 cc of normal saline).

Details of the Procedure

In cases of vertical malposition, the inframammary fold is reset at the appropriate location determined with the patient in the standing position. To lower the fold, the capsule is incised with electrocautery along the entirety of its inferior margin and dissection is carried down over the chest wall to the appropriate location translated from the skin markings. The IMF is then reset by securing the pectoralis muscle/fascia and superficial fascial attachments to the chest wall with interrupted 0 Ethibond figure-of-eight sutures (Fig. 14.2). Non-absorbable sutures are used given the higher risk of inferior migration and failure of the capsulorraphy under the weight of the implant. The incisions are then temporarily closed with staples and the patient is sat up to confirm correct repositioning; any further adjustments are made as needed.

In cases of inferior implant malposition and an inframammary fold that is too low, an inferior capsulorrhaphy is performed in a similar fashion at the level of the new desired location of the fold. The capsulorrhaphy is performed using interrupted figure-of-eight 0 Ethibond sutures along the inferior aspect of the implant pocket at the appropriate level. If the fold is being relocated from its native position, it is important to obliterate all fascial attachments through the subcutaneous layer to the skin to prevent the appearance of banding along the lower pole of the breast.

In the case of implant lateralization, semi-circumferential capsulotomy is performed along the medial aspect of the pocket overlying the chest wall to allow for medialization of the implant. Partial capsulectomy can also be utilized in this region with dissection carried medially as needed to allow for adequate implant movement (Fig. 14.3). The implant can be balloted medially to confirm sufficient medial movement and plan placement of lateral capsulorrhaphy sutures to close down the pocket and prevent lateralization. Capsulorrhaphy is performed using interrupted 0 Ethibond figure-of-eight sutures. A small strip of capsule can be removed in the suture line prior to performing capsulorrhaphy to ensure adherence of the two layers of capsule to each other. In cases of implant medialization and

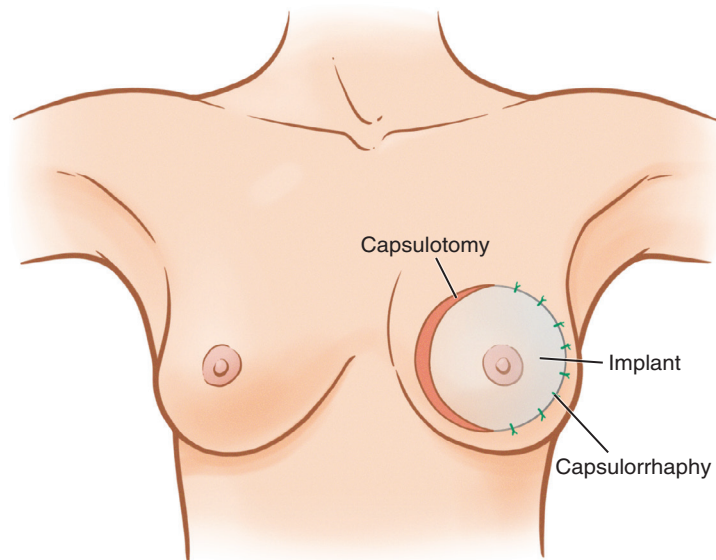


• **Fig. 14.2** Adjustment of inframammary fold. In cases of a high-riding implant, the inframammary fold is lowered to the appropriate position by performing a capsulotomy (red arrow) along the inferior margin of the implant pocket and securing the capsule and overlying ADM or muscle (grey dotted lines) to the chest wall in the new location. (Adapted from Kim J, Connor C. Focus on technique: two-stage implant-based breast reconstruction. *Plast Reconstr Surg.* 2012;130(5S-2):104–115S, Figure 5.)

symmastia, implant lateralization is performed by utilizing capsulorrhaphy medially and capsulotomy/capsulectomy laterally in a similar fashion. Adjunctive meshes or ADM are particularly useful to reinforce the medial implant pocket during correction of symmastia. Lastly, radial capsulotomies may be employed to improve outward projection of the reconstructed breast in focal areas of restriction due to capsule formation.

When implant exchange is warranted, an implant sizer is placed in the pocket after removal of the old implant. If a smaller implant is being placed, capsulorrhaphy will often be performed as described above, usually to further close down the lateral aspect of the implant pocket and prevent lateral implant migration. If a larger implant is being placed, some capsulotomy may be warranted for better redraping of the soft tissues over the larger prosthesis depending on the degree of size change. With form-stable implants, the pocket needs to be as close to the exact size as possible to minimize the risk of implant migration.

In implant exchange performed for capsular contracture, a total or near total capsulectomy is first performed. During capsulectomy, it is critical to remove only the capsule and



• **Fig. 14.3** Correction of lateral implant malposition. Medialization of an implant to correct lateral malposition entails performing a medial capsulotomy to the extent needed and closing down the lateral pocket with reinforced capsulorrhaphy sutures to prevent lateral migration of the implant. (Adapted from Chasan P, Francis C. Capsulorrhaphy for revisionary breast surgery. *Aesth Surg J*. 2008;28(1):63–69, Figure 1D.)

preserve the overlying muscle and soft tissues. Any pocket adjustments are performed to optimize implant position and the pocket is thoroughly irrigated with triple antibiotic solution. New implants are subsequently placed to remove biofilm sources on the prior implant. In cases of prepectoral reconstruction, consideration should be given to pocket change to a submuscular or dual-plane pocket to further minimize risk of recurrent contracture.

In cases of severe animation deformity, pocket change can be performed to the prepectoral plane. Prior to pocket change, adequate skin laxity and quality as well as sufficient adipose tissue should be confirmed. After implant removal, a partial or total capsulectomy can be performed as needed though is not typically necessary. The inferior edge of the pectoralis muscle is divided from the acellular dermal matrix in dual-plane reconstructions. The subpectoral pocket is closed by suturing the edge of the pectoralis major down to the chest wall with interrupted figure-of-eight Vicryl sutures. Subsequently, creation of a neo-prepectoral pocket is performed just over the pectoralis muscle. Care is taken to preserve the adipofascial tissue, particularly with thin mastectomy flaps, and minimize trauma to the flaps to ensure perfusion. A drain is utilized as a new pocket is created and a potential space now exists under the muscle. Prior to setting the drain to self-suction, the skin envelope and nipple–areola complexes are placed in the desired position. Prepectoral conversion may be performed in conjunction with fat grafting, particularly if the patient has thin mastectomy flaps resulting in implant visibility.

Synthetic and biosynthetic scaffolds can be used as adjuncts in several different implant-based revision procedures. Our preferred ADM is contoured, fenestrated human acellular dermal matrix. For mesh, we are using

poly-4-hydroxybutyrate (P4HB). In cases of IMF repositioning, ADM or mesh may be used to bolster and support the new IMF. The ADM or mesh is sutured posteriorly to the chest wall and anteriorly to the anterior wall of the capsule using interrupted 2-0 PDS sutures. Placement of the ADM/mesh at the appropriate tension is critical to prevent the material from folding onto itself if too loose and not making contact with the underlying tissues if too tight; integration of the ADM/mesh is compromised in both situations.

Scaffolds, such as ADM, may also be useful in providing soft tissue support in the setting of rippling, which usually occurs in the superomedial quadrant of the breast. In these situations, an appropriately sized piece of ADM is placed as an underlay against the implant capsule in the area of most noticeable rippling to further augment soft tissue thickness. In cases of rippling with the implant initially placed in the prepectoral plane, conversion to a submuscular or dual-plane reconstruction should be considered. Fat grafting can also be used to augment tissue thickness in the superomedial breast. More recently, we are using highly cohesive round, smooth implants to treat rippling.

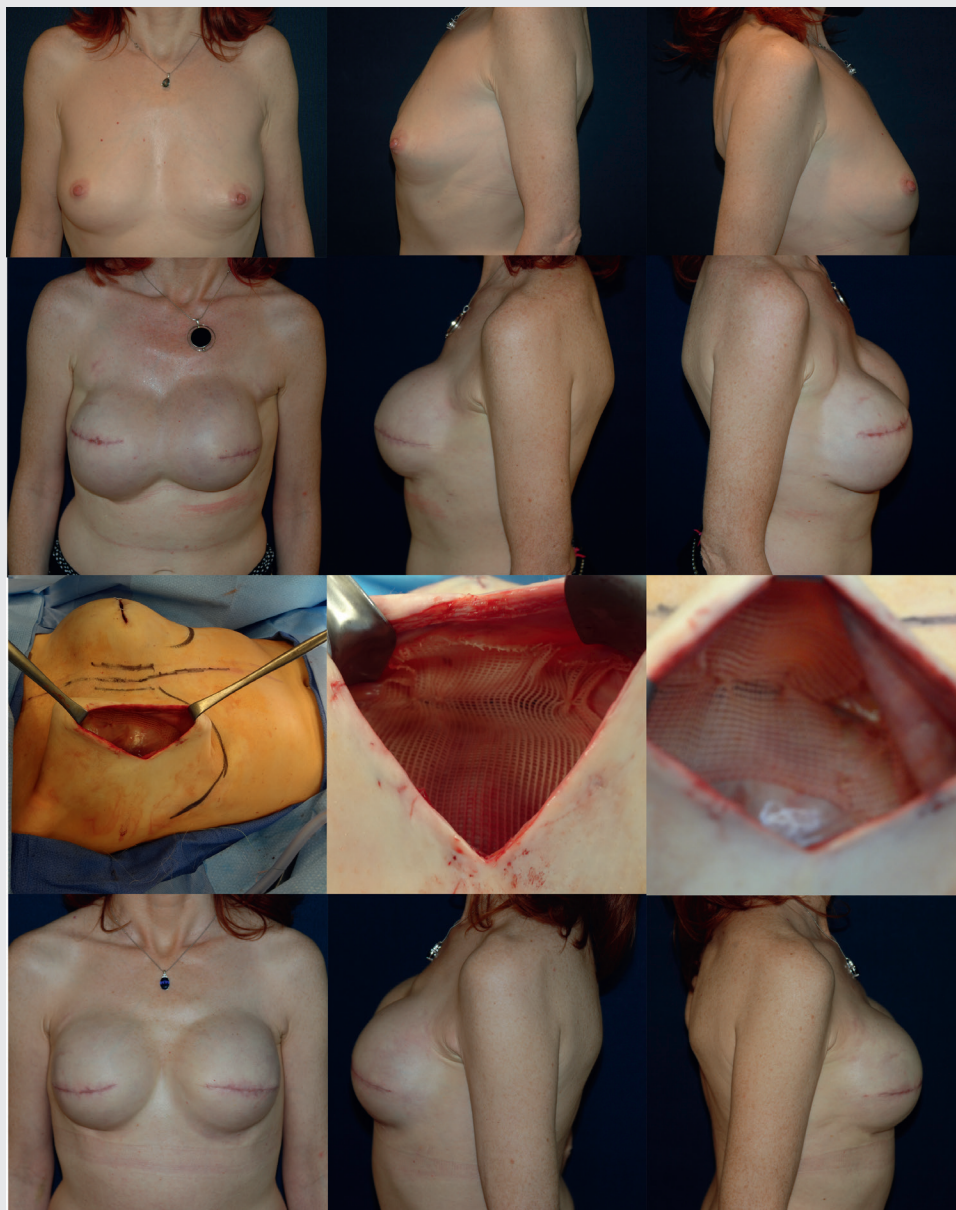
After all revisions have been performed, the implant pocket is irrigated again with triple antibiotic solution. The incisions are temporarily stapled and the patient is sat up for a final time to check symmetry and confirm a satisfactory result. The incisions are subsequently closed in a layered fashion. Interrupted 2-0 Vicryl sutures with the knots facing outwards are utilized to close the capsule and repair the pectoralis muscle using a malleable retractor to protect the implant. Finally, the skin edges are closed using a subcuticular monofilament suture after any devitalized or damaged tissue is sharply debrided.

Case Examples

CASE 14.1

This 49-year-old female ([Case 14.1.1](#)) with left-sided Paget's disease underwent total mastectomies followed by immediate submuscular tissue-expander placement and subsequent implant exchange with 450-cc high profile, smooth, round implants. The patient subsequently developed symmastia and breast asymmetry secondary to right IMF and implant descent (second row). Revisions included capsule plication medially and reinforcement with SERI surgical scaffold to correct

symmastia (third row). The right inframammary fold was elevated with capsulorrhaphy and reinforced with SERI scaffold. Bilateral implants were downsized to 400-cc high profile, smooth, round implants. Final postoperative images (bottom row) show restoration of normal medial contour of breasts with correction of symmastia and anatomic, symmetric IMF location.

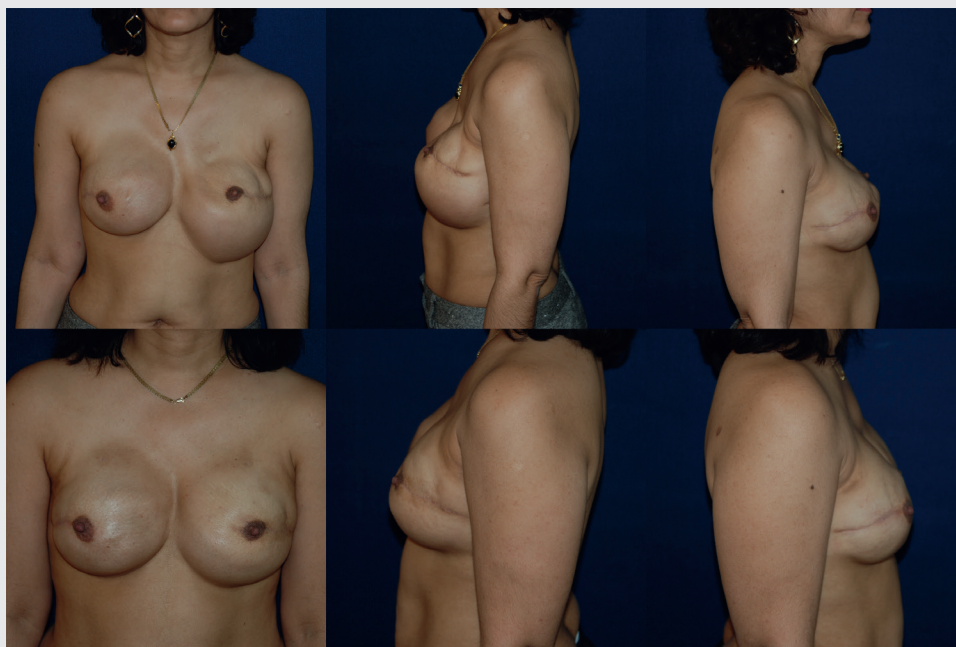


• Case 14.1.1

CASE 14.2

This 49-year-old BRCA2-positive female underwent bilateral nipple-sparing mastectomies and dual-plane single-stage reconstruction with another provider. This was complicated by bilateral mastectomy flap necrosis and left breast implant exposure requiring explantation with delayed left-sided tissue-expander placement and bilateral implant exchange. The patient presented to us with left implant bottoming-out and loss of the IMF with secondary nipple asymmetry, right

breast rippling, and concavity of the bilateral upper poles (Case 14.2.1). The patient underwent right implant exchange (600-cc high profile smooth, round) and ADM placement to treat rippling as well as left implant downsizing (475-cc high profile smooth, round) and IMF elevation with SERI scaffold reinforcement. She additionally had bilateral upper pole fat grafting to address contour deformities.

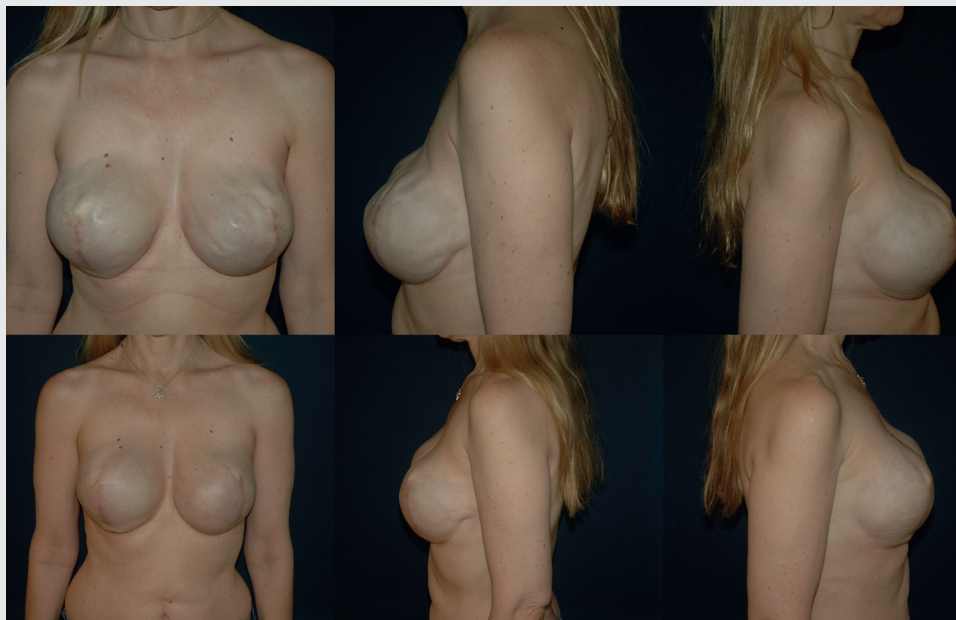


• Case 14.2.1

CASE 14.3

This is a 54-year-old patient with left ductal carcinoma who underwent bilateral total mastectomies and implant-based reconstruction at an outside institution. She presented with bilateral rippling of the upper breast poles as well as inferolateral displacement of bilateral implants (Case 14.3.1).

The patient underwent capsulorrhaphy of the bilateral inferolateral implant pockets and implant exchange to 600-cc extra-high profile smooth, round implants as well as fat grafting to the bilateral upper poles to improve rippling.



• Case 14.3.1

CASE 14.4

This 46-year-old patient underwent bilateral nipple-sparing mastectomy and implant-based breast reconstruction for right breast cancer 8 years previously at an outside institution. The patient was unhappy with her result. She was most bothered by the lack of upper pole fullness and the unnatural feel of her

breasts. She was offered both implant revision and autologous reconstruction. She chose to undergo bilateral DIEP flaps. [Case 14.4.1](#) shows preoperative (above) and two years postoperative results (below).



• Case 14.4.1

Postoperative Care and Expected Outcomes

Incisions are dressed with adhesive tape strips and overlying non-adhesive gauze and an occlusive dressing. Patients are almost always discharged the same day after revision procedures, and occasionally the subsequent day. Ambulation is encouraged on the day of surgery and patients are instructed to refrain from heavy lifting, strenuous activity or exercise for at least two weeks. If a drain was placed, a short course of oral antibiotics covering skin flora is also prescribed. Patients without drains are allowed to shower normally, without submersion of incisions in water, starting two days after surgery. Patients with drains are instructed to sponge-bathe only and keep drain sites dry until drains are removed, when output is less than 30 mL for two consecutive days.

Management of Complications

Complications after revision of implant-based reconstruction are relatively uncommon. Ischemic complications are exceedingly rare; however, care must still be taken with gentle tissue handling and preservation of capsule and perforator-based perfusion to the skin, particularly in patients with a large breast skin envelope. Partial-thickness mastectomy flap or NAC necrosis can be managed with local wound

care. Full-thickness necrosis should be managed aggressively with excision and closure. Infectious complications are also relatively rare, but must be diagnosed and treated expeditiously to prevent compromise of the prosthesis.

Recurrence of particular deformities with time is also a possibility that must be discussed with the patient. In core silicone implant trials, risk rates for capsular contracture, implant malposition and rippling were 26.8%, 8% and 12.8% in patients that had already undergone revision of implant-based reconstruction.⁶ Patients are likely to require further surgery over time for correction of asymmetries that arise with aging and persistent foreign-body reactions around an implant. Discussing these risks up front with the patient will help set appropriate expectations for outcomes after revision of implant-based reconstruction.

Secondary Procedures

Tertiary revisions after revision of implant-based breast reconstruction are often for similar indications. The most common reasons for reoperation after implant-based reconstruction revision have been reported to be capsular contracture, implant malposition and patient request for style/size change.⁶ Nipple–areola complex position is also a critical factor that must be taken into consideration while evaluating breast asymmetry and performing revision procedures. In our experience with nipple-sparing mastectomy, implant-based

reconstruction was found to be an independent negative predictor for NAC repositioning; however, 63.6% of the 77 NAC malposition corrections (7.4% of total cases) in our series were in implant-based reconstructions. In alloplastic reconstruction, the most common repositioning techniques were crescentic skin excision (36%) and capsule modification (28%), compared to mastopexy techniques in autologous reconstructions.¹⁰

Conclusions

Revision of implant-based breast reconstruction is relatively common over the long term. Indications for revision include vertical or horizontal implant malposition, breast size discrepancies, contour deformities, nipple malposition, capsular contracture and requests for style or size changes by the patient. Several different techniques are available to correct common aesthetic and functional complications after alloplastic reconstruction including IMF repositioning, capsulorrhaphy, capsulotomy, capsulectomy, implant exchange, pocket changes and utilization of acellular dermal matrix. During revisions, manipulation of the skin, fascial structures, capsule and implant should be considered independently while concomitantly envisioning the effects of changes in each structure on the reconstruction as a whole. Success with revision can be attributed to careful preoperative planning, meticulous atraumatic handling of the tissues and respect for anatomic boundaries, repeated re-examination of cosmetic results in the operating room and thorough preoperative patient counseling and follow-up.

PEARLS FOR SUCCESS

- Vertical malposition is best treated by identifying the inframammary fold preoperatively and utilizing combined capsulotomy and capsulorrhaphy to reset the fold in the appropriate location.
- Horizontal malposition is corrected using a combination of capsulotomy (or capsulectomy), as well as capsulorrhaphy to close down potential spaces and ensure durable medial or lateral repositioning of the implant.
- Treatment of capsular contracture requires total or near-total capsulectomy, pocket manipulation as needed, implant exchange, and frequently ADM.
- If converting dual-plane or subpectoral reconstructions to the prepectoral space for animation deformity, it is critical to evaluate for skin quality and laxity as well as sufficient subcutaneous tissue to identify appropriate candidates for pocket change.
- Biologic and synthetic scaffolds can be used to reinforce the inframammary fold in implant repositioning, surface the implant pocket in treatment of capsular contracture and provide extra soft tissue support when addressing rippling deformities.
- Position of the native or reconstructed nipple–areola complex must be kept in mind during all revision procedures to prevent malposition.
- Safety during revision surgery is critical; gentle tissue handling, preservation of vascularity, and cognizance of the capability of the skin and soft tissues to be manipulated is key to preventing compromise of the reconstruction.

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15

Partial Breast Reconstruction With Flaps

MOUSTAPHA HAMDİ AND GABRIELE GIUNTA

Introduction

Breast conserving therapy (BCT) with partial mastectomy followed by radiation therapy is the gold standard of early stage invasive breast cancer treatment, with an equivalent 5-year survival rate to that of mastectomy alone with stage I or II breast cancer.¹

Partial mastectomy includes both lumpectomy and quadrantectomy. Oncoplastic surgery, the combination of partial mastectomy with partial breast reconstruction reduces potential breast deformities and results in aesthetic breast reshaping. The first aim of oncoplastic surgery is avoiding mastectomy with complete cancer ablation and clear surgical margins without the distortion of the natural shape of the breast. The main steps of oncoplastic approach are free margin cancer ablation, optimal scar orientation, breast tissue rearrangement and, when indicated, contralateral breast reshaping in order to achieve symmetry.²

Indications and Contraindications

Patients often require surgery after partial mastectomy to correct volume discrepancy, contour deformity and nipple malposition.³ The resection of more than 15%–20% of the breast parenchyma in a small-volume (A or B cup) breast and more than 30% in larger breast will determinate volumetric deformities and bilateral asymmetries (Fig. 15.1). Patients with small or non-ptotic breasts could require volume replacement. In addition, radiotherapy distorts the shape of the breast, initially causing breast edema and skin erythema and eventually causing parenchymal fibrosis, retraction, skin atrophy, hyper-/hypopigmentation, and telangiectasia. The long-term results of radiation are difficult to predict but stabilize 1–3 years after radiation.⁴ Furthermore, oncoplastic surgery extends the indications for breast conservation surgery to allow the resection of much larger tumors relative to breast size.⁵ In these patients, partial

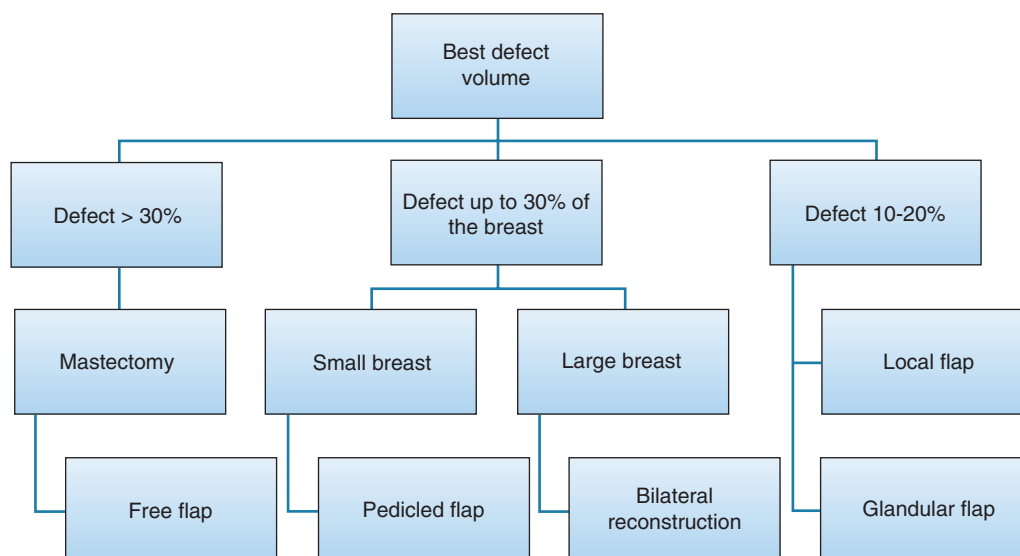
breast reconstruction with flaps could be considered as an important part of whole breast cancer treatment.

The main indication for pedicled flaps is immediate or delayed partial breast reconstruction when volume replacement is necessary. However, other conditions will require locoregional flaps in partial breast reconstruction. These flaps can be utilized as a salvage procedure after partial/total previous free flap loss for breast reconstruction. They can be combined with implants in breast reconstruction as well.

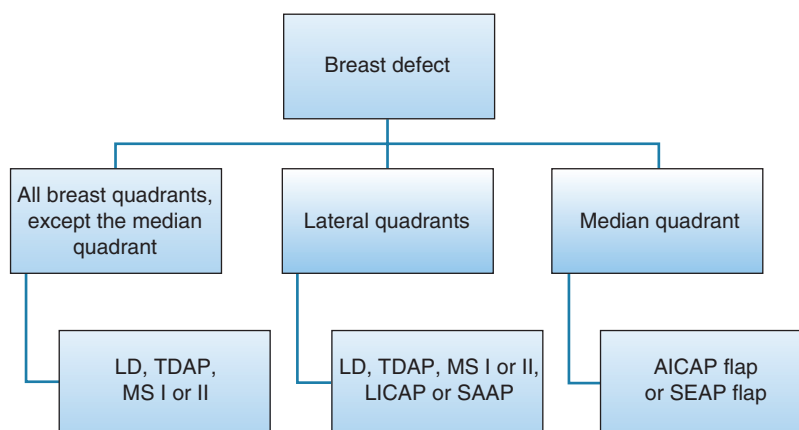
Previous axillary or thoracic surgery with damage to the thoracodorsal vessels is a contraindication for latissimus dorsi flap or thoracodorsal artery perforator (TDAP) flap; these patients may be candidates for a lateral intercostal artery perforator (LICAP) flap. Previous scars and irradiation to the area may also result in the limitation of local pedicled perforator flaps⁶ (Fig. 15.2). However, when breast deformity after partial mastectomy and radiotherapy is severe, the optimal choice is to perform a complete mastectomy and autologous reconstruction with a free flap transfer.

Preoperative Evaluation and Special Considerations

Preoperative evaluation of the patient must be standardized and detailed. Any previous breast surgery should be taken into account when planning BCT. Different body types, skin laxity and fat distribution are important factors in the decision-making process. Breast physical examination must include the evaluation of breast skin elasticity and thickness, scars and any defining marks such as tattoos, stretch marks and contour irregularities. Breast shape, grade of ptosis, and size are determinants of success in surgical treatment. The base and width of the breast, the width of the nipple–areola complex (NAC), the height of the nipple and the distance from the sternal notch, midline and inframammary fold must be recorded in detail. Any natural breast asymmetry



• **Fig. 15.1** Partial breast reconstruction: a decision-making process.



• **Fig. 15.2** Indications of partial breast reconstruction with flaps.

should be pointed out to the patient before surgery. Furthermore, palpation for masses or abnormalities in the breast parenchyma, nipple examination and detailed documentation of breast sensation are mandatory.

In planning the approach to treat the partial mastectomy defect, the primary decision that must be made is whether reconstructive surgery will be needed after the tumor excision. Poor cosmetic outcomes after partial mastectomies can occur from both the amount of breast tissue removed and/or the site of the cancer. Partial breast reconstruction with flaps depends on the size of the tumor, its anatomical location, and the amount of tissue resection required to achieve free margins in relation to the volume of the breast.

There are two basic types of surgical techniques in partial breast reconstruction: volume displacement and volume replacement techniques.² Volume replacement techniques are the focus of this chapter. They are used in small to moderate-sized breasts or when the tumor/breast ratio is large and the residual breast tissue is insufficient for

the reshaping and the replacement of the defect. Volume replacement is performed with non-breast local or distant flaps offering both tissue for the filling of the glandular defect and the skin deficiency of the reconstructed breast.

When volume replacement is necessary, the decision of which technique will be used is determined mostly by the surgeon's experience and the size of the defect in relation to the size of the remaining breast. The non-breast locoregional flaps offer extra tissue required in large tumor excisions/quadrantectomies for the replacement of the breast volume, however they can be more demanding procedures and associated with donor-site and flap morbidity. Small lateral defects can be easily repaired with skin rotation flaps or lateral thoracic axial flaps. However, most of these fasciocutaneous flaps may be unavailable in patients who have had axillary lymph node dissection. The latissimus dorsi muscle (LD) or musculocutaneous flaps have been very popular as a method of choice in partial breast reconstruction.⁴ On the other hand, local pedicled perforator flaps have

• BOX 15.1 Aesthetic Subunits of the Breast

- The breast skin to the areola
- The areola to the nipple
- The breast skin to the chest wall at the inframammary fold
- The anterior axillary line
- The breast to the sternal skin

Different aesthetic breast subunits have been proposed according to the tissue, color and texture differences.

(From Losken A, Hamdi M. Partial Breast Reconstruction – Techniques in Oncoplastic Surgery. New York, NY: Thieme Medical Publishers Inc; 2017.)

allowed surgeons to replace large defects with the minimum donor-site morbidity. Fasciocutaneous perforator flaps offer sufficient soft tissue coverage while sparing the muscle and tend to have a lower seroma rate.

Surgical Techniques

Relevant Surgical Anatomy

Breast and plastic surgeons must have a thorough understanding of breast anatomy, physiology and the standards of aesthetically pleasing breast shape. Oncoplastic surgeons should consider the aesthetic breast subunits when planning both cosmetic quadrantectomies and reconstructions (Box 15.1).^{4,7}

The Latissimus Dorsi (LD) Flap

The LD flap has the advantage of having a constant anatomy.⁸ The blood supply of the latissimus dorsi comes from the thoracodorsal artery, a terminal branch of the subscapular artery. The subscapular artery runs about 5 cm before splitting into the scapular circumflex and the thoracodorsal arteries. The thoracodorsal artery is about 2–4 mm in diameter and it courses along the posterior axillary fold for about 8–14 cm before piercing the latissimus dorsi on its costal surface. The thoracodorsal artery gives off one or two branches to the serratus anterior muscle and one branch to the overlying skin. The basic pattern of the thoracodorsal bundle (artery, nerve and 1–2 venae comitantes) branches into a lateral (vertical) and a medial (horizontal) branch. The lateral branch follows a course parallel to the muscle fibers, 1–4 cm medial to the free lateral border of the muscle and gives off perforating vessels that supply the skin. The smaller medial branch diverges at an angle of 45 degrees and travels medially. Also, perforating vessels from the intercostal and lumbar arteries supply the muscle and overlying skin.⁸

The TDAP Flap

The thoracodorsal artery perforator (TDAP) flap is based on the perforators from the descending (vertical) or horizontal branches of the thoracodorsal vessels (Video 15.1). Anatomic studies on cadavers showed the presence of 2–3 musculocutaneous perforators from the vertical branch. The

proximal perforator enters in the subcutaneous plane obliquely 8–10 cm distal to the posterior axillary fold and 2–3 cm posterior to the anterior border of the muscle. The second perforator is located 2–4 cm distally to the first one. Occasionally, a direct cutaneous perforator arising from the thoracodorsal vessel passes around the anterior border of the muscle, making flap harvesting easier.

There may not be always a single reliable perforator for the TDAP flap, due to anatomical variations.⁹ In this case the surgeon must be aware and be prepared to modify the flap dissection intraoperatively into a muscle-sparing TDAP flap.

The TDAP flaps are classified as follows¹⁰:

- *Standard TDAP flap*, when no muscle component is included in the flap.
- *TDAP-MS-I*, where a small cuff of muscle (4×2 cm) is included near the perforator vessels. The muscle segment protects the perforators from excessive tension and provides more freedom in flap positioning.
- *TDAP-MS-II*, where multiple small perforators are encountered and a larger segment, up to 5 cm wide, along the anterior border of the latissimus dorsi muscle together with the descending branch of the thoracodorsal vessels is then included within the flap in order to insure a maximal blood supply to the skin paddle (Fig. 15.3).

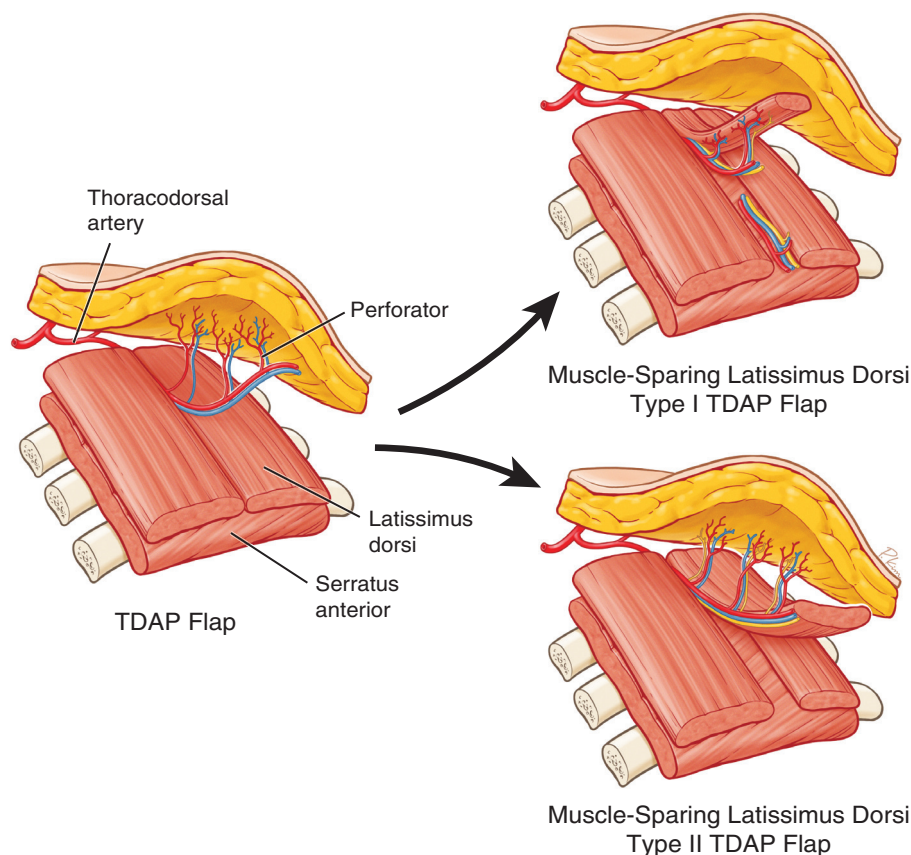
The ICAP Flap

The intercostal artery perforator (ICAP) flap is based on perforators arising from the intercostal vessels. The intercostal vessels provide an arcade between the aorta and the internal mammary vessels and are classified in four segments: vertebral, intercostal, intermuscular and rectus segments.¹¹

The ICAP flaps are classified as follows:

- *Dorsal intercostal artery perforator (DICAP) flap*: the flap is based on perforators from the vertebral segment of the intercostal vessels.
- *The lateral intercostal artery perforator (LICAP) flap*, based on perforators arising from the intercostal segment.
- *Anterior intercostal artery perforator (AICAP) flap*: the nutrient perforators of this flap arise from the muscular or rectus segment.

The intercostal is the longest (12 cm) segment and it is very important because it gives 5–7 musculocutaneous perforators. The lateral intercostal artery perforator (LICAP), commonly used in breast surgery, originates from the costal segment of the intercostal vessels. The largest perforator is most frequently found in the sixth intercostal space, from 0.8 to 3.5 cm from the anterior border of the latissimus dorsi muscle. The pedicle has adequate length, allowing the rotation of the flap up to 180 degrees without tension and with no need to extend the dissection into the costal groove. An intercostal nerve may be included in the harvesting if ICAP-sensate flap is needed. For small defects, the LICAP is designed on the lateral aspect of the thorax and for moderate to large defects the distal limit of the skin pad can



• **Fig. 15.3** TDAP anatomy. (Adapted from Hamdi M, Salgarello M, Barone-Adesi L, Van Landuyt K. Use of the thoracodorsal artery perforator (TDAP) flap with implant in breast reconstruction. *Ann Plast Surg.* 2008;61(2):143–146.)

reach the posterior thoracic region, planned in a fashion similar to the skin pad of an LD flap.

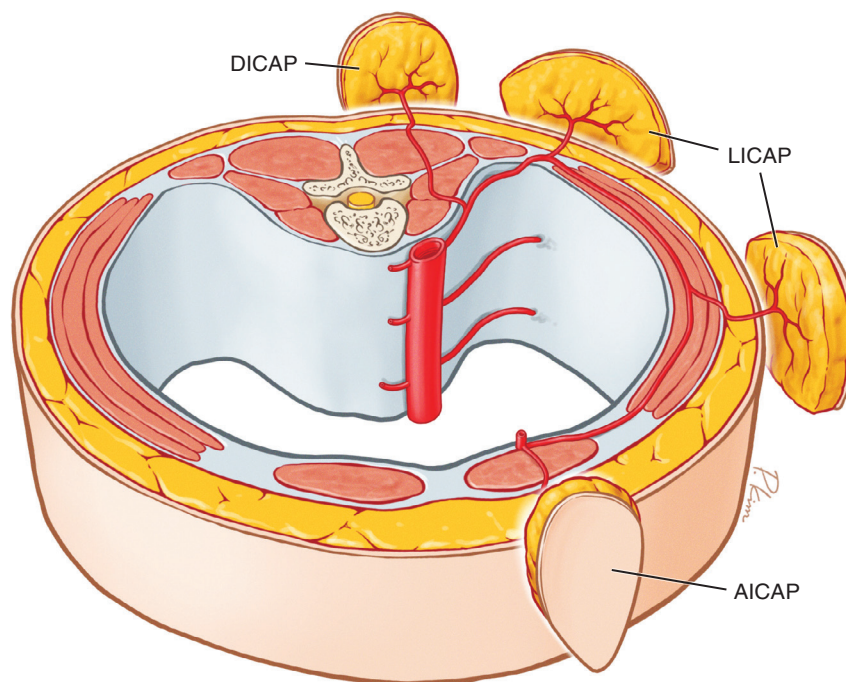
The AICAP flap is outlined over the upper abdomen, so that the final scar will be hidden under the bra strap. The donor site can be closed primarily if it is up to 6 cm wide (preoperative pinch test) or in a reversed abdominoplasty fashion (Fig. 15.4).

Preoperative Markings

Perforator mapping simplifies flap marking and can be performed using a portable ultrasound system.

To localize the thoracodorsal perforators, a unidirectional handheld Doppler (8 Hz) ultrasonography examination is performed in the planned skin flap area. However, although this device is handy, it has the disadvantage of generating both false negative and false positive perforators and provides less detailed anatomic vessel information. This is due to the misleading background signal from the thoracodorsal vessels, which can be confusing and difficult to distinguish from the perforator signal. To avoid this, during the test, the patient is positioned in the lateral surgical position with 90 degrees of shoulder abduction and 90 degrees of elbow flexion. Preoperative, CTA scan can be also used to accurately identify the perforators.¹² The patient

is preferably marked the day before surgery. In immediate reconstruction, the breast and the tumor size and location as well as the final defect size are estimated. The skin incisions of the partial mastectomy are planned both for oncologic and aesthetic purposes. The TDAP flap, planned for the partial breast reconstruction, is designed to include the traced perforators (one or more) at the proximal part if feasible, in the directions of relaxed skin lines, under the bra line, or even horizontally according to the patient's preference. The pinch test estimates the skin laxity and fat excess in the lateral thorax and backing area. The size of the flap is determined by the need for defect coverage and averages 20×8 cm. The skin marking is performed at first with the patient in an upright position and the anterior border of the LD muscle is palpated and also marked. Then the patient is placed in a lateral decubitus position, with the reconstruction side facing upwards, for the perforator mapping and the flap design. The skin island is always extended over the anterior border of the latissimus dorsi to include the premuscular perforators if present. The proximal border of the flap approximates the inframammary fold. If the defect is more medial, the flap is designed more distally, further onto the back. The LICAP flap design follows the same rules, however the flap is placed more anteriorly, towards the breast. When AICAP flaps are chosen for partial breast



• **Fig. 15.4** The ICAP flap. Different perforators arise from the intercostal vascular arcade. Based on these perforators the dorsal intercostal artery perforator (DICAP) flap, the lateral intercostal artery perforator (LICAP) flap, and the anterior intercostal artery perforator (AICAP) flap can be harvested. (Adapted from Hamdi M, Van Landuyt K, de Frene B, et al. The versatility of the inter-costal artery perforator (ICAP) flaps *J Plast Reconstr Aesthet Surg.* 2006;59(6):644–652.)

reconstruction, these flaps are usually designed under the IMF along the rib.

Surgical Exposure and Details of Procedure

The patient is prepped and positioned in supine position for the partial breast mastectomy. When the lumpectomy/quadrantectomy is completed, clips are placed in the wound bed in order to mark the area for radiation therapy. If the reconstructive plan provides for a TDAP or LICAP flap, the patient is positioned and prepped again in lateral position as for LD flap dissection. Otherwise, for AICAP flaps the patient remains in the supine position. The flap harvesting starts with skin incisions. A posterior approach is usually used in the TDAP flap. The surgeon continues dissection down to the LD in the suprafascial plane, while beveling the flap in order to gain as much extra tissue as possible. Harvesting proceeds from the back towards the axillary region. The dissection continues meticulously, under loupe magnification, until the perforator vessel is visualized.

If the perforator has a visible pulsation and is adequate in caliber (>0.5 mm) the dissection continues along the perforator course up to the thoracodorsal pedicle. If a longer pedicle length is required, the TD vessels can be dissected up to their subscapular vessel origin and included in the flap. If the perforator has an intramuscular course, the dissection is achieved in the direction of the muscle fibers and any nerves that come across should be carefully preserved.

All the perforator side branches within the muscles fibers are either ligated or coagulated. If two perforators are found along the same row, they can both be included within the flap, without sacrificing any muscle fibers. In case of inadequate perforator size, the flap is converted to a muscle-sparing LD, preserving a small cuff of muscle attached to the posterior wall of the perforators, sacrificing only few fibers and, most important, preserving the muscle innervation. This adjustment is also useful when the flap is planned for the medial breast reconstruction, because it protects the perforators from tension. The flap harvesting carries on, with the skin incisions continued proximal to the axilla and lateral to the LD and the dissection proceeds anteriorly, until the flap is freed from the donor site and left connected only to the vascular pedicle.

The flap is tunneled in a subcutaneous tunnel in the axilla–lateral thoracic area to the recipient breast area, avoiding any injury to the pedicle. The donor site is closed in three anatomical layers, a drain is placed and the patient is returned again to the supine position. Before the final inset, the flap can be partially or totally de-epithelialized and folded if needed to give extra projection to the reconstructed breast mound. In LICAP flap dissection, an anterior approach is performed from the breast towards the anterior-free border of LD muscle. Perforator dissection is done within the serratus muscle until reaching its origin from the costal groove. Further dissection is usually not needed.

Case Examples

CASE 15.1

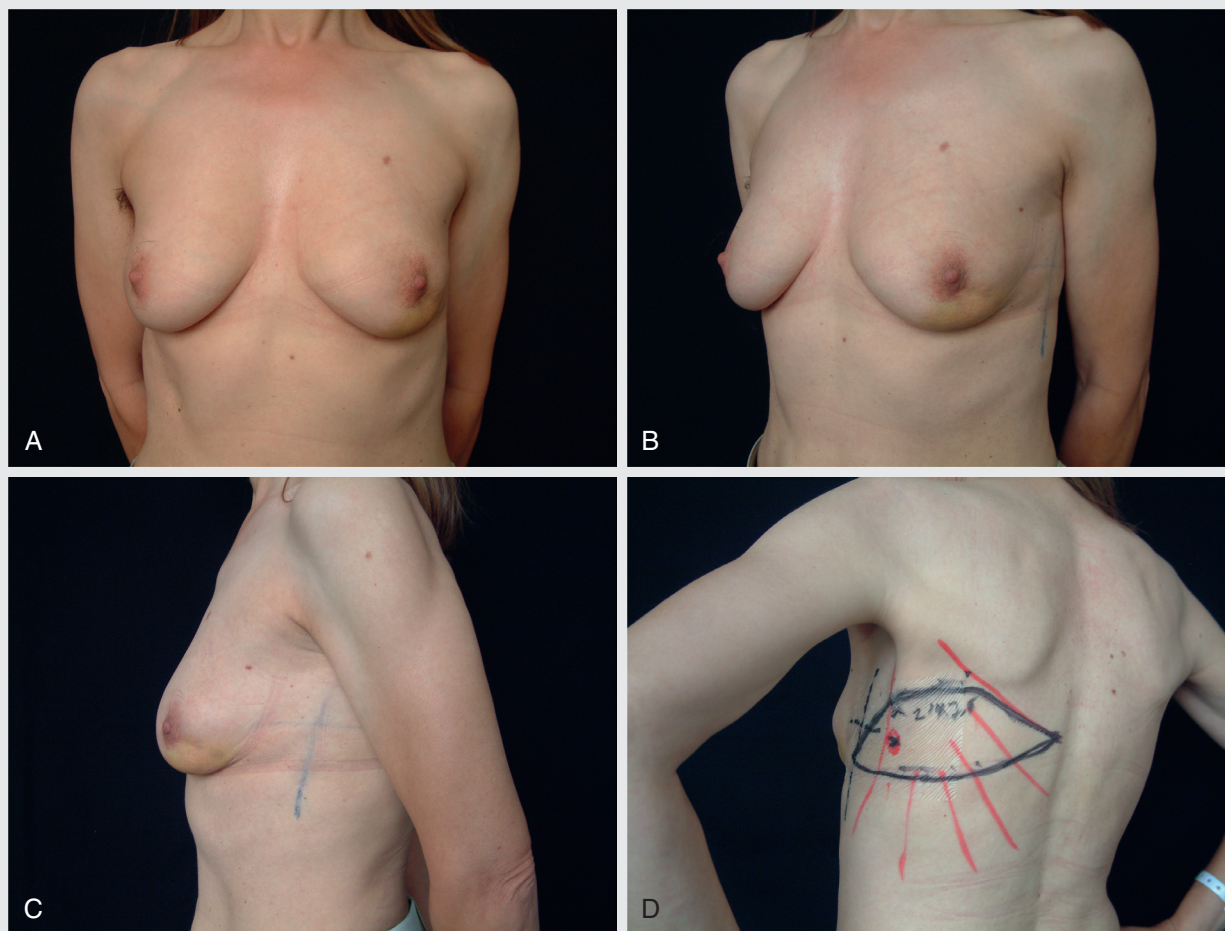
A 49-year-old patient with a ductal carcinoma over the junction of the lateral quadrant of the left breast. The patient was a good candidate for quadrantectomy with axillary dissection and immediate partial breast reconstruction with a TDAP flap.

Case 15.1.1 shows the preoperative views (A–C) and surgical markings (D). The perforator was located using a CT-angiogram and confirmed by the Doppler examination. A skin paddle measured 21 × 7.5 cm was outlined at the lateral thoracic area.

The quadrantectomy and TDAP flap harvesting was done with the patient in the lateral position. The quadrantectomy

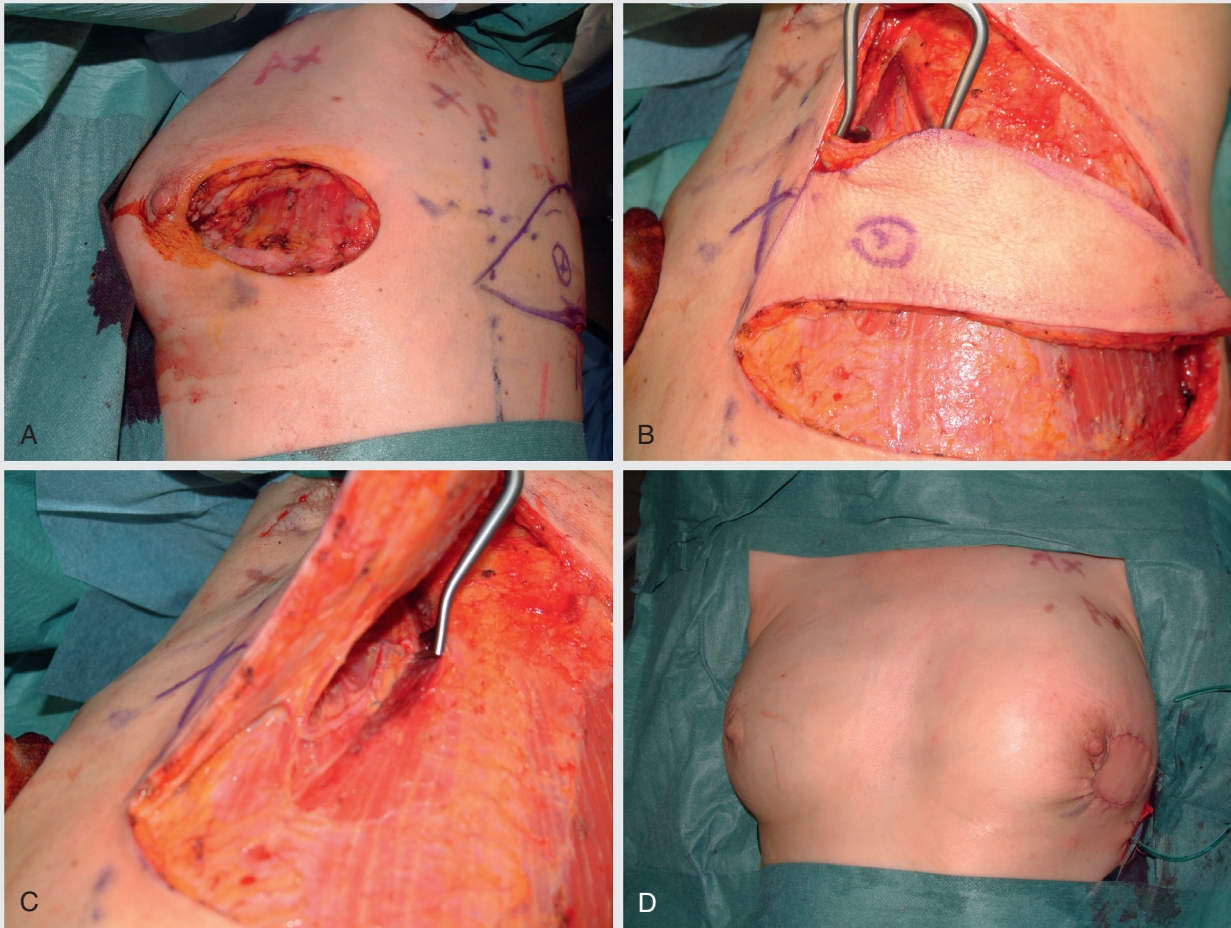
was performed including the overlying breast skin (Case 15.1.2A). The thoracodorsal artery perforator was found by posterior approach to the marking zone (Case 15.1.2B). The perforator was dissected between the LD muscle, based on the descending branch (Case 15.1.2C). The flap was transferred to the defect and the patient was turned to the supine position (15.1.2D).

Postoperative views at one year are shown in Case 15.1.3. Case 15.1.4 shows the donor site preoperatively (A) and postoperatively (B). The scar is inconspicuous and the LD muscle contour was preserved.

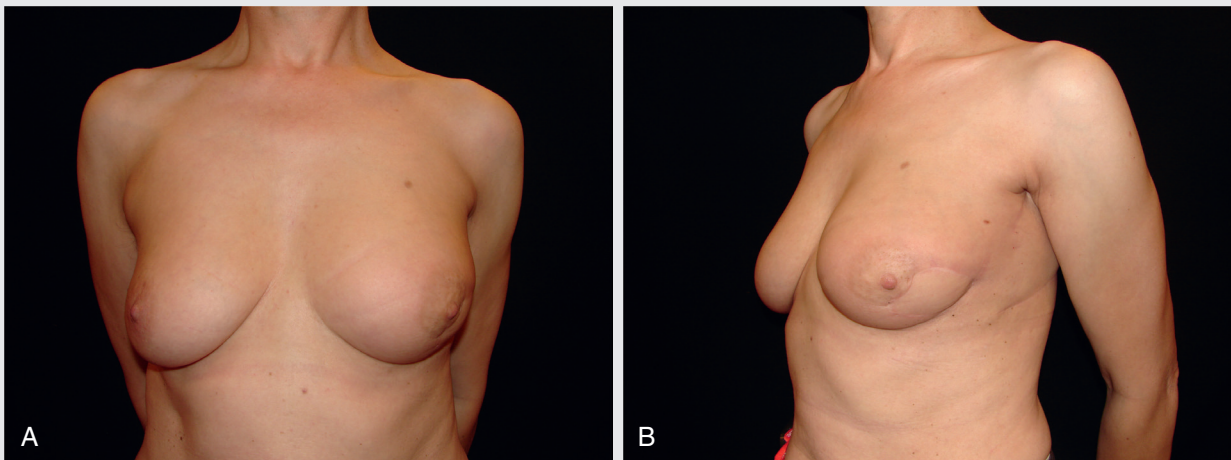


• Case 15.1.1

CASE 15.1—cont'd



• Case 15.1.2



• Case 15.1.3

*Continued**Continued*

CASE 15.1—cont'd



• Case 15.1.3, cont'd



• Case 15.1.4

CASE 15.2

A 44-year-old patient with a ductal carcinoma over the junction of the lateral quadrant of the right breast. The patient underwent a lumpectomy with nipple-areola centralization by the breast surgeon (Case 15.2.1). Unfortunately, the margins were involved. The patient was a good candidate for further resection and immediate partial breast reconstruction with a pedicled perforator flap.

The perforators were located by Doppler examination (Case 15.2.2A). Two perforators were localized, the closest one to the defect was presumed to be an intercostal and the other one was presumed to be a thoracodorsal perforator. A skin paddle was modified upward to include both perforators at the lateral thoracic area (Case 15.2.2B). The flap was extended posteriorly with two versions, a short one if the intercostal

perforator was chosen and a longer one if the thoracodorsal perforator was chosen during the surgery (Case 15.2.2C).

The oncological resection was done with the patient in lateral position and the intercostal perforators were first explored by anterior approach (Case 15.2.3A). The short version flap was then incised (Case 15.2.3B). The LICAP flap was dissected from the underlying LD muscle (Case 15.2.3C). The flap was turned 180 degrees to reach the defect (Case 15.2.3D). The skin was de-epithelialized leaving a small skin paddle (Case 15.2.3E).

Postoperative views are shown in Case 15.2.4. The patient could leave the hospital after 2 days, after the drain removal from the donor site. The donor site with the resulting scar is shown in Case 15.2.4D.

CASE 15.2—cont'd



A



B



C

• Case 15.2.1

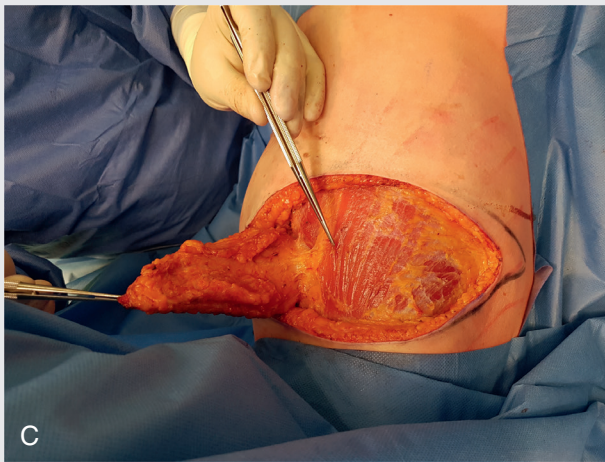
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CASE 15.2—cont'd



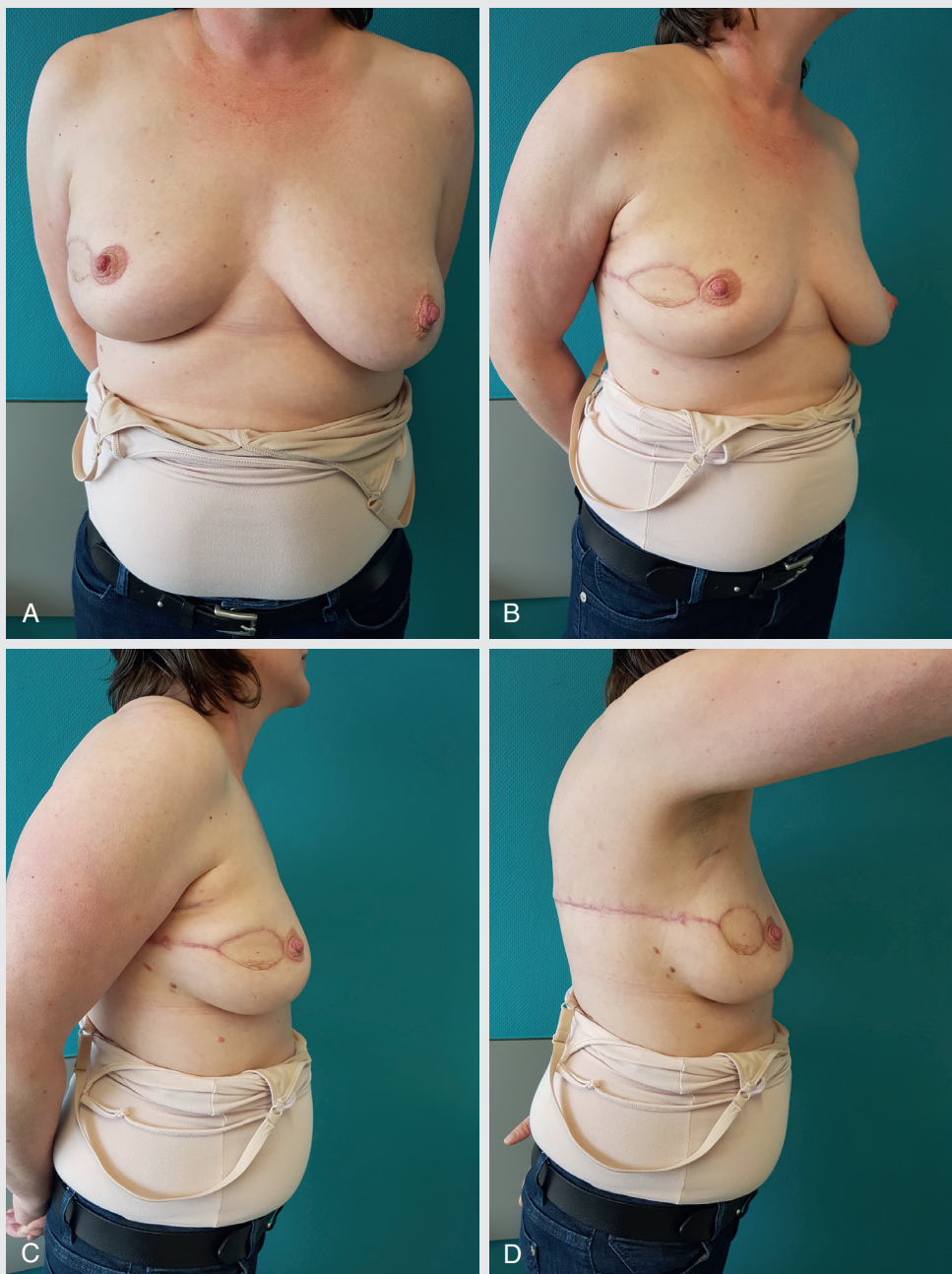
• Case 15.2.2

CASE 15.2—cont'd



• Case 15.2.3

CASE 15.2—cont'd



• Case 15.2.4

CASE 15.3

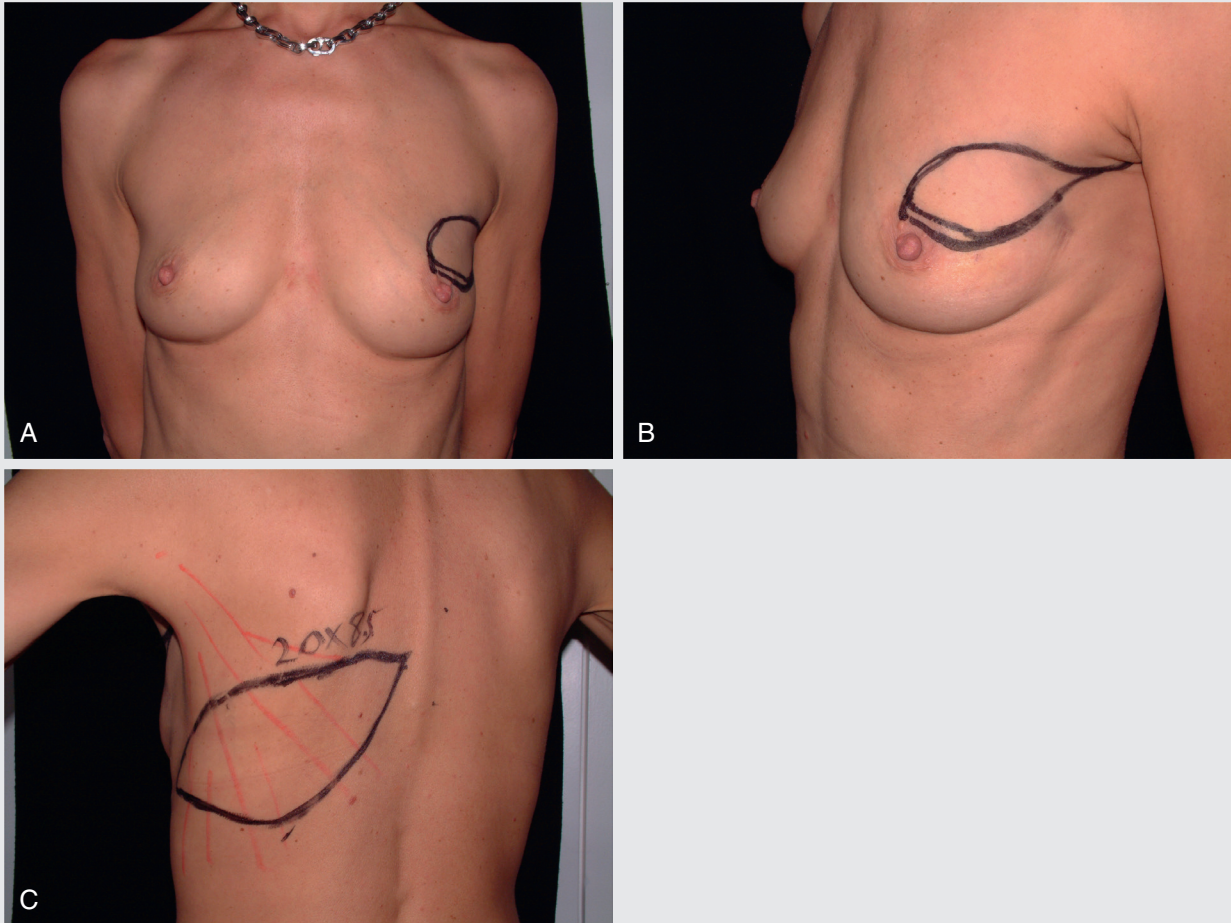
A 42-year-old patient with a ductal carcinoma within the superolateral quadrant of the left breast. The tumor was close to the skin.

Case 15.3.1 shows (A,B) preoperative views with the amount of skin resection including the underlying tumor, and (C) the surgical markings. A skin paddle measuring 20×8.5 cm was planned.

A muscle sparing latissimus dorsi flap was harvested. The skin incision was made (Case 15.3.2A). The flap was based on

the descending branch of the thoracodorsal vessels (Case 15.3.2B). This technique spares more than 80% of the LD muscle. The flap was transferred to the defect and the patient was turned to the supine position (Case 15.3.2C).

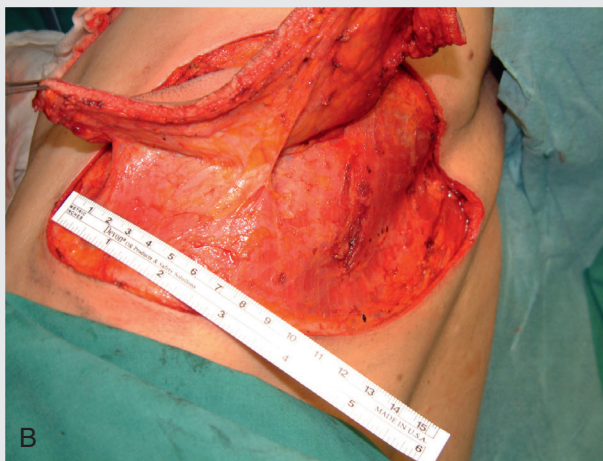
Case 15.3.3 shows the postoperative result of partial breast reconstruction with muscle-sparing LD flap (A,B) and the donor site (C,D) at one year.



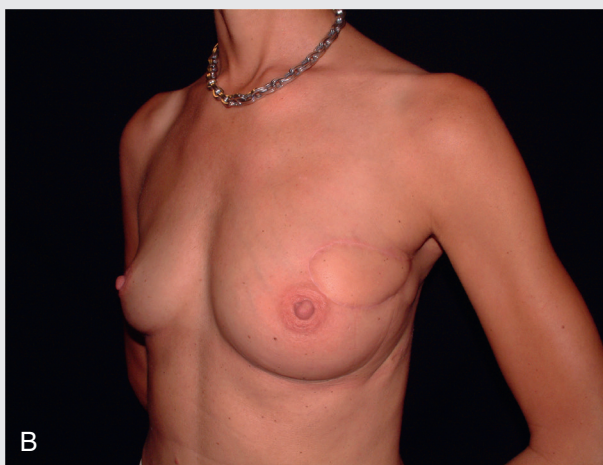
• Case 15.3.1

Continued

CASE 15.3—cont'd



• Case 15.3.2



• Case 15.3.3

CASE 15.3—cont'd



• Case 15.3.3, cont'd

Postoperative Care and Expected Outcomes

Postoperatively, standard perforator flap monitoring is followed. Patients receive low-molecular-weight heparin (LMWH) during the relative immobilization time. The arm is held in 45 degree abduction. Arm stretching is restricted for a week.

Patients are discharged home in a stable condition, when the drains are removed, on average 3–5 days postoperatively, and physiotherapy can be started. Most patients require between 9 and 14 sessions of shoulder physiotherapy. Some patients who undergo reconstruction with a TDAP flap document an initial decrease in forward arm elevation and passive abduction, which recovers over time. Patients treated for BCT with pedicled perforator flaps have a short rehabilitation course. Adjuvant breast radiation therapy can be started 6 weeks postoperatively, and chemotherapy, if indicated, can start 3 weeks postoperatively. Most patients receive the chemotherapy first. Partial breast reconstruction with flaps may give a “plugged in” appearance, which seems to be slightly improved after radiation therapy. It is hard to calculate the long-term outcomes of partial breast reconstruction with pedicled perforator flaps due to the unpredictable impact of radiation therapy in the final result.

Rearrangement of parenchymal tissues, scar tissue and fat necrosis are common in oncoplastic surgery and these consequences might be suspicious on several radiological imaging modalities. In case of suspicious lesions, biopsy with fine needle aspiration, core biopsy or excisional biopsy

can be necessary to rule out tumor recurrence (up to 25%). However, the breast reshaping does not interfere with mammographic sensitivity, and qualitative changes are similar to those found following breast conservation therapy alone.^{3,5}

Management of Complications

The average complication rate was 14% in oncoplastic flap reconstruction cases. The complication rate of BCT alone was 25.9%, although early complication rates were not routinely reported.⁵ Donor-site morbidity in partial breast reconstruction is reduced to a minimum using locoregional pedicle perforator flaps. Seroma is the most common donor-site complication. According to a recent study, the seroma rate in TDAP-MS-II flaps is 5.5%, while there are no seromas in perforator flaps. Seromas are usually treated conservatively with aspiration.

Other postoperative complications observed were wound dehiscence (4%), infection (2%) and hematoma (2%). Partial or total flap losses are rare. Fat necrosis of the flap has been observed and can usually be treated, if necessary, by its excision and primary closure or reconstruction with another local flap. In those cases of extensive necrosis, a mastectomy with total breast reconstruction can be indicated.¹³ Pathologic scars, flap contractures and volume loss are rare sequelae and may need secondary procedures.

Secondary Procedures

Our experience showed stable results long-term. However, breast asymmetry due to the different aging process between

the two breasts can be observed because the non-irradiated side may become more ptotic when compared to the irradiated side. The irradiated breast may also atrophy. When the breast asymmetry is noticeable, fat grafting and/or contralateral breast reshaping is indicated. Lipofilling alone or combined with other reconstruction options for the treatment of post-oncological breast defects is gaining great popularity.

In larger cancer removals, partial breast reconstruction can be followed by fat grafting, improving the final outcome. Lipofilling may be used at the same time as the breast conserving surgery to limit volume discrepancies between the two breasts.

In second-stage procedures, fat grafting can be performed in order to make adjustments in volume, projection or contour irregularities due to partial fat necrosis or flap contractures. Fat grafting is also used for the treatment of the breast skin atrophy after irradiation. In these patients, the adipose stem cells present in the fat are infiltrated in the intradermal plane to improve the scars. The major disadvantage of this technique is that it is time-consuming and extends the operation time significantly.³

Conclusions

Breast conservation therapy is considered the gold standard in the treatment of early-stage breast cancer. Oncoplastic surgery simultaneously combines the oncologic and aesthetic procedures. The main indication for pedicled flaps is immediate or delayed partial breast reconstruction when volume replacement is necessary. The harvesting of a local perforator flap has a long learning curve, requiring a sufficient knowledge of the anatomy of the area. Secondary procedures such as breast lipofilling and contralateral breast reshaping may be required to reach breast symmetry at long-term follow-up.

PEARLS FOR SUCCESS

- Partial breast reconstruction with pedicled flap is an alternative to mastectomy and total breast reconstruction in selected patients.
- Proper patient selection is mandatory in oncoplastic surgery.
- Latissimus dorsi (LD) flaps or fasciocutaneous perforator flaps are the first choice in partial breast reconstruction with flaps.
- A long learning curve is required in partial breast reconstruction with perforator flaps.
- Perforator mapping and correct flap marking is the keystone in this technique.
- Pedicled flaps are indicated in high tumor/breast size ratio.
- Overcorrection is essential when pedicled flaps are performed in partial breast reconstruction.
- Secondary procedures may be required to achieve breast symmetry at long-term follow-up.

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16

Partial Breast Reconstruction With Local Tissue Rearrangements

ALEXANDRE MENDONÇA MUNHOZ

Introduction

Breast conservation surgery (BCS) has become an alternative technique to mastectomies as a consequence of its lower morbidity, sensitivity preservation and equivalent overall survival rate.^{1,2} BCS reconstruction consists of a concept that combines BCS with techniques of breast reshaping in order to improve the final aesthetic outcome and to expand the indications for breast conservation without decreasing oncological safety.

Recently, increasing attention has been focused on BCS reconstructive procedures.^{2–15} Among the main techniques, glandular flaps, skin/fat local flaps and mastopexy/mammaplasty are most commonly used with more satisfactory results.^{2–4} The selection of a best technique is determined by the surgeon's experience and the volume of the BCS defect in relation to the volume of the remaining breast tissue.^{3,4} The main positive aspects of the reconstructive technique should include reproducibility, low interference with the oncologic treatment and long-term results (Box 16.1).

This chapter describes local tissue rearrangement (LTR) techniques, which allow the use of remaining breast/local tissue following BCS by glandular flaps, local flaps or glandular reshaping techniques for better aesthetic results. Thorough understanding of these techniques and an adequate consideration of the patient's breast volume, tumor location, excised volume, and volume of the remaining breast tissue in choosing appropriate surgical techniques will result in a satisfactory outcome. In some cases and depending on the excised volume and the initial breast volume, surgery of the contralateral breast may be necessary to improve symmetry. In addition, the timing of such surgery and the advantages of synchronous versus delayed approaches should also be pointed out.

Indications/Contraindications of LTR

LTR techniques are defined when the BCS defect is reconstructed using one of a range of breast or local flaps,

advanced into the lumpectomy defect.¹⁵ Different techniques have been described to repair small or moderate defects. These procedures are all based on advancement or rotation of an area of breast or local tissue to reconstruct the BCS. According to the breast volume, ptosis, and tumor size/location, the patients are evaluated by the plastic surgeon who decides each type of indicated reconstruction. During intraoperative evaluation, the partial breast defects in relation to the initial breast volume, the size and location of the defect, and the amount of tissue available are evaluated and an appropriate procedure can be selected (Box 16.2).

The advantage of the immediate reconstruction is that the whole procedure can be achieved in a one-stage surgery. Because there is no scar tissue, a tissue rearrangement is easier and the aesthetic outcome can be more predictable.^{3,4} In terms of oncological safety, immediate approach can obtain a widely negative margin around the tumor as a result of wider local tissue excision.¹⁴ This aspect is advantageous and has the potential of reducing the incidence of margin involvement and development of local recurrence.^{4–6,14} In spite of the advantages, the immediate reconstruction has some negative aspects and can be time-consuming and require specialist training to properly apply these techniques.⁴ In addition, radiation therapy usually involves some degree of fibrosis and shrinkage of the remaining breast tissue. Thus, the aesthetic outcome may be unpredictable. Another negative aspect of immediate reconstruction relates to uncertainties about surgical margin involvement and the necessity to return to surgery for re-excision.⁴

Preoperative/Intraoperative Evaluation and Special Considerations

The preoperative evaluation is based on our previously described classification system for breast conservation surgery defects.⁴ This system is based on the breast volume, the extent/location of glandular tissue resection, and the remaining available breast tissue. Basically, in patients with

small breasts without ptosis and defects that do not cause volume distortion in the breast shape, LTR based on breast flaps can be utilized with a satisfactory outcome. In patients with medium/large-sized breasts, mammoplasty technique is indicated^{6–8} (Table 16.1).

Usually, the reconstruction techniques are performed with one of five surgical options: breast tissue advancement flaps, local flaps, bilateral mammoplasty, latissimus dorsi myocutaneous flaps, and complete skin-sparing mastectomy with total reconstruction. The main indications for LTR are for types IA, IIA, and IIIA. In this scenario breast defects are reconstructed with breast tissue advancement flaps in which the defect created is usually spherical or rectangular. The breast tissue is advanced along the chest wall or beneath the breast skin flap to fill the tumor defect.

In type IB, the lateral thoracodorsal flap can be indicated for lateral defects.^{5,11–13} This flap can be planned as

• BOX 16.1 Advantages of Local Tissue Rearrangement Reconstruction

Simple procedure
Less morbidity
Similar skin (color and texture)
Short operative time
Fast recovery
Low interference with the oncologic treatment

• BOX 16.2 Good Candidates for Local Tissue Rearrangement Reconstruction

Conservative breast surgery
Unifocal tumors
Small-volume breasts with small resection (type IA)
Medium-volume breasts with small/moderate resection (type IIA and IIB)
Large-volume breasts with small/moderate resection (type IIIA and IIIB)
Free surgical margins (frozen sections)

a wedge-shaped triangle located on the lateral aspect of the thorax and then rotated to the breast defect. For small defects, the flap is planned as a triangle located exclusively on the lateral aspect of the thorax.⁵ In type IIB, breast defects are most frequently reconstructed with breast tissue advancement flaps and associated mastopexy techniques. The same concept can be applied for types IIIA and IIIB. Defects classified as C (I, II and III) are not adequate to be reconstructed by LTR.

Frequently, type IC defects are converted to a skin-sparing mastectomy and reconstructed with an appropriate technique for each case. Type IIC and IIIC defects should be analyzed individually according to the size of the breast defect in relation to the remaining tissue available. For this purpose, the patient is positioned upright to assess the amount of glandular tissue. Thus, type IIC/IIIC can be subclassified into favorable and unfavorable defects. If there is enough tissue to perform an adequate breast mound shaping, the defect is classified as favorable. For lateral defects, the extended lateral thoracodorsal flap is most commonly used where the inferior and superior limits are designed more obliquely with curved borders to incorporate a large amount of tissue.⁵

In patients with central/medial defects, the extended latissimus dorsi myocutaneous flap can be used. Conversely, if not enough breast tissue remains, the breast defect is classified as unfavorable and a skin-sparing mastectomy is indicated. In type IIIC defects, sometimes the defect is favorable and the deficiency is most frequently reconstructed with bilateral reduction mammoplasty. A marked reshaping of the breast with available tissue and a similar contralateral breast reduction is then performed (Fig. 16.1).

Surgical Techniques

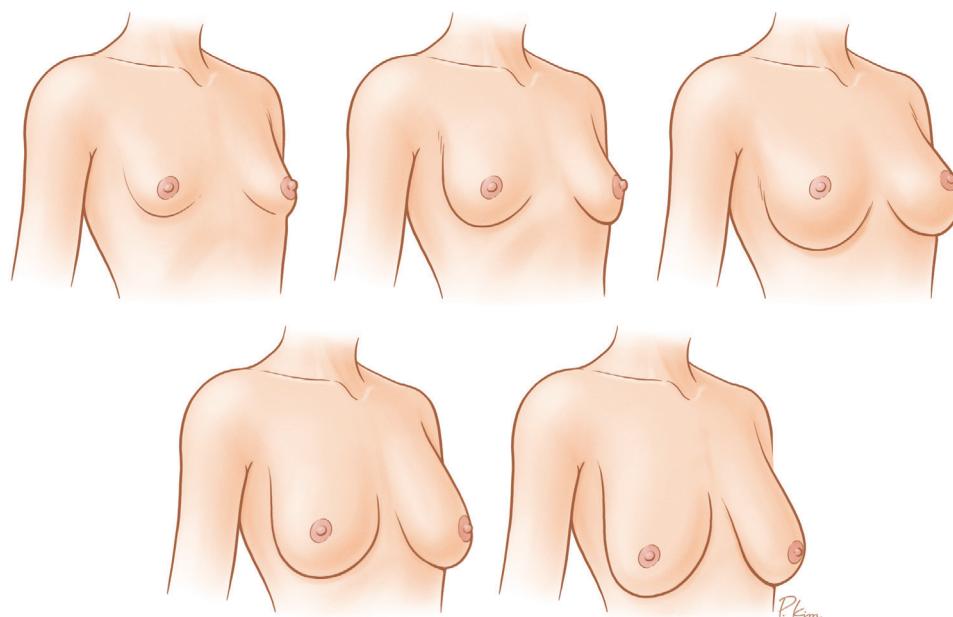
Relevant Surgical Anatomy

LTRs are based on breast tissue advancement flaps that are supplied by glandular arteries from three main arteries. The great part of the breast tissue extends inferiorly from the level of the second or third rib to the inframammary fold (at the level of the sixth or seventh rib). The breast tissue

TABLE 16.1 Immediate Conservative Breast Surgery Reconstruction Based on the Type of Breast and Extent of Defect

Type I			Type II			Type III		
Small volume without ptosis Cup size: A/B			Medium volume with/without ptosis Cup size: C			Large volume with ptosis Cup size: D		
A	B	C	A	B	C	A	B	C
Small defects	Moderate defect	Large defects	Small defects	Moderate defect	Large defect	Small defect	Moderate defect	Severe defect
Without distortion	Moderate distortion	Severe distortion	Without distortion	Small/mod distortion	Mod/severe distortion	Without distortion	Small distortion	Mod/severe distortion

(Adapted from Munhoz AM, Montag E, Gemperli R. Oncoplastic breast surgery: indications, techniques and perspectives. *Gland Surg.* 2013;2(3):143–157.)



• **Fig. 16.1** Breast defects. (Adapted from Munhoz AM, Montag E, Gemperli R. Oncoplastic breast surgery: indications, techniques and perspectives. *Gland Surg.* 2013;2(3):143–157.)

also extends into the axilla as the glandular tail of Spence, which can be used as a glandular flap. The posterior surface of the breast tissue rests on portions of the fasciae of the pectoralis major, serratus anterior, external abdominal oblique, and rectus abdominis muscles.

The LTA usually arises from the axillary artery and supplies up to 30% of breast blood flow to the lateral and upper outer aspects of the breast. The branches course inferomedially within the subcutaneous tissue to effect anastomoses with branches of the internal mammary artery (IMA) and internal carotid artery (ICA) in the areolar area. The III, IV, and V posterior ICA are the least important arteries supplying the breast.

Preoperative Markings

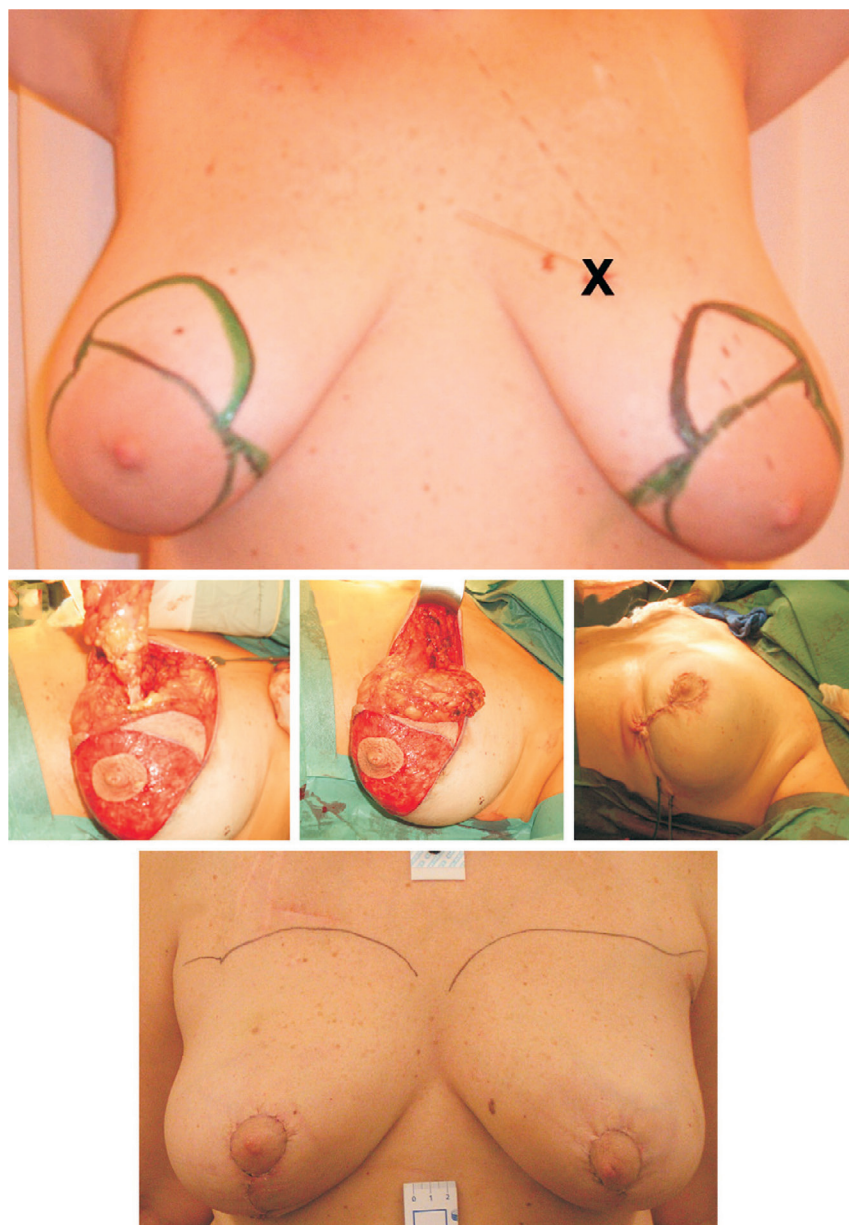
Despite the simplicity of the LTR techniques, important technical steps must be planned beforehand. Operative planning should include tumor location and the extent of glandular tissue resected, addressing individual reconstructive requirements, thus enabling each patient to receive an individual “custom-made” reconstruction. The success of the procedure depends on patient selection, coordinated planning with the oncological surgeon and careful intraoperative management. In addition, an in-depth dialog concerning alternatives for BCS reconstruction should be undertaken within a multidisciplinary scenario, including the risks and positive aspects of the LTR reconstruction. Usually for any type II or III candidate for immediate BCS, we perform a mammaplasty planning based on classical markings. After the BCS and with an appropriate intraoperative evaluation, we can follow these marks and perform the mammaplasty or, in cases of subtype A, convert to an LTR with breast tissue advancement flaps.

Basic Markings

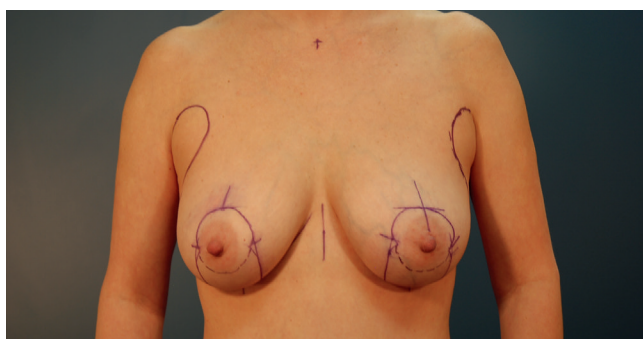
With the patient in an upright standing position, the breasts are examined and the vertical axis as well as the pre-existing inframammary fold are marked. If the breast presents some degree of ptosis, the new nipple–areola complex (NAC) position is defined. For this purpose, the projection of the inframammary fold onto the anterior surface of the breast is drawn and it will indicate the new position of the upper border of the NAC (point A). The new areola is then marked, and a semicircle is drawn. The diameter of this semicircle will vary according to the size of the breast and the amount of breast tissue to be resected. Although the markings for the reduced areola may be made at this point, we usually prefer to perform this intraoperatively. Thus, these markings are not rigid and have to be checked again after the BCS. Points B and C are marked by pinching the skin at the level of the nipple, and seeing the amount of excisable skin in the horizontal plane. Usually, points AB and AC are joined as a curved line, and the transposition of points A, B, and C to the contralateral breast is done with the aid of suture lines placed over the sternal notch and the xiphoid appendix (Figs. 16.2–16.4).

Details of Procedure

In its simplest variety of LTR, a full-thickness flap of breast tissue is advanced on the chest wall or beneath the skin envelope. Once the margins of the defect are properly mobilized, the breast defect is closed. In the situation where the tumor is located away from the NAC (more than 5 cm in small and medium-volume breasts), the skin incision can be planned as a parallelogram with the two margins of the same length in order to avoid dog-earing after the primary



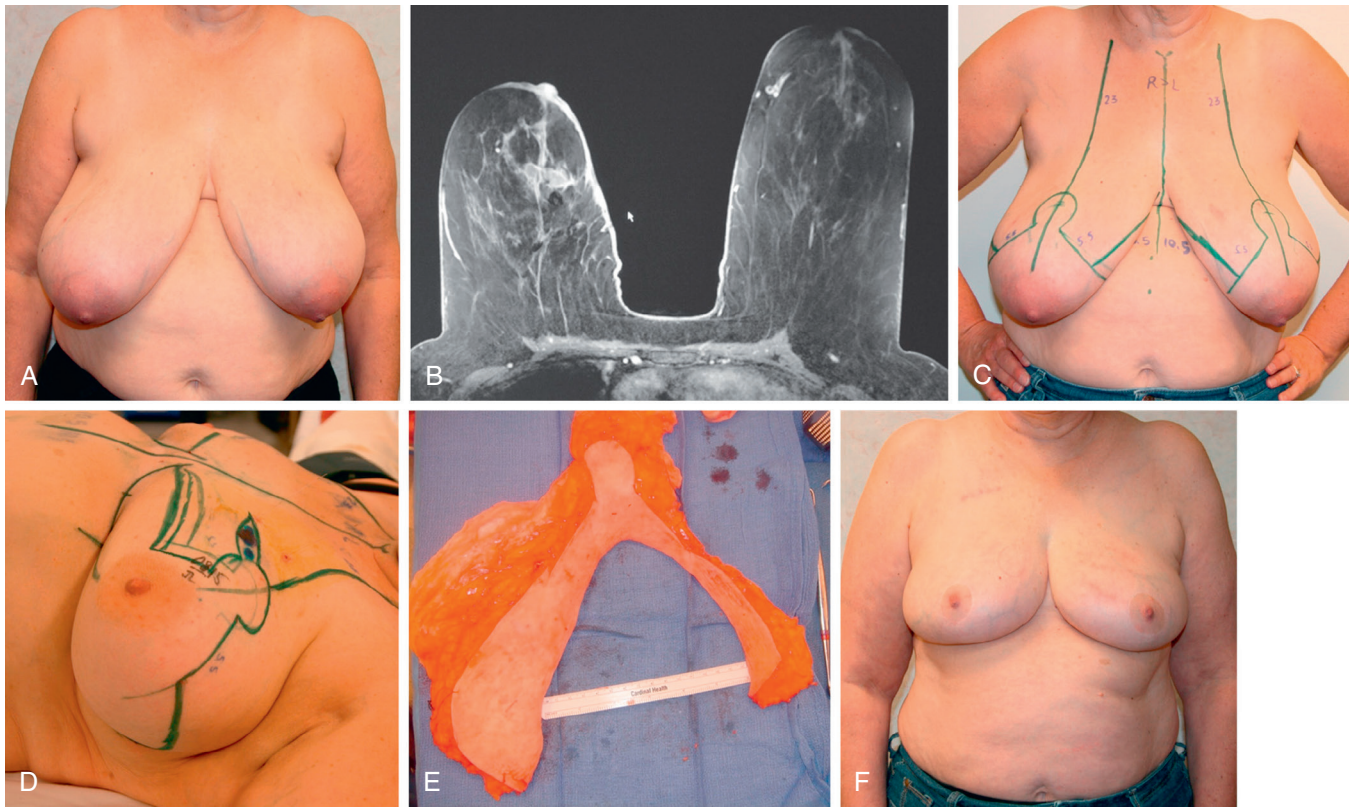
• **Fig. 16.2** An oncoplastic procedure for central and medio-cranial breast cancer. (Reprinted from Fitzal F. An oncoplastic procedure for central and medio-cranial breast cancer. *Eur J Surg Oncol.* 2007; 33(10):1158–1163. Copyright © 2007 Elsevier Ltd.)



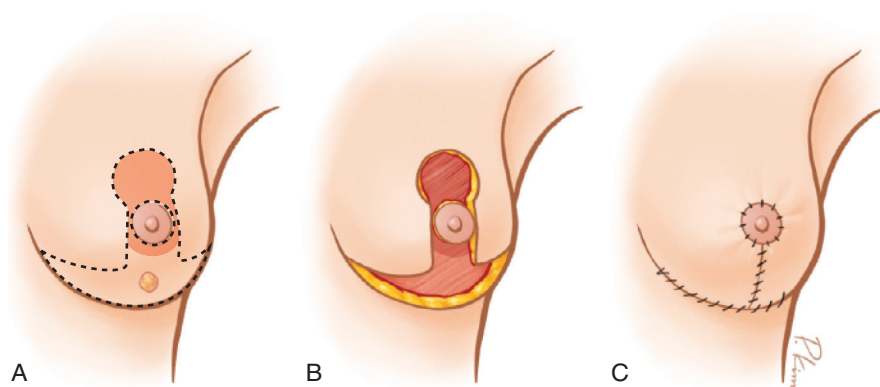
• **Fig. 16.3** Mastopexy. (Reprinted from Neligan PC. *Core Procedures in Plastic Surgery*. Chapter 15. Elsevier Saunders; 2014:233–253. Copyright © 2014, Elsevier Inc. All rights reserved.)

closure. Following BCS, glandular tissues around the incision are dissected and undergo glandular reshaping to maintain the breast shape. The negative aspect of this technique is an increased scar length. In addition, care must be taken to avoid too much skin to prevent shifting of the NAC. In this situation, sometimes a contralateral procedure may be necessary to achieve a satisfactory outcome (Fig. 16.5; see also Case 16.1.1).

In the situation where the tumor is located very close to the NAC and a central lumpectomy is indicated, the NAC is excised along with the tumor. Breast defects following BCS are repaired after undermining the nearby glandular tissue and the incision is closed by a continuous running



• **Fig. 16.4** Split reduction technique: a 56-year-old woman (A) presented with a left-breast invasive carcinoma and ductal carcinoma *in situ* of the upper inner quadrant, spanning 19 mm on mammography. (B) Preoperative magnetic resonance imaging. She underwent a split reduction excision of the tumor (C,D) with negative margins (E). In addition, the index breast was significantly reduced, and a contralateral Wise pattern reduction was performed for symmetry. The final results (F) are shown 1 year after adjuvant radiotherapy to the left breast. (Reprinted from O'Kelly Priddy CM, et al. The new paradigm: oncoplastic breast conservation surgery. In: Bland K, Copeland E, Klimberg VS, Gradishar W. *The Breast: Comprehensive Management of Benign and Malignant Diseases*, 5th ed. 2018;40:576–589.e1. Copyright © 2018 by Elsevier Inc. All rights reserved.)



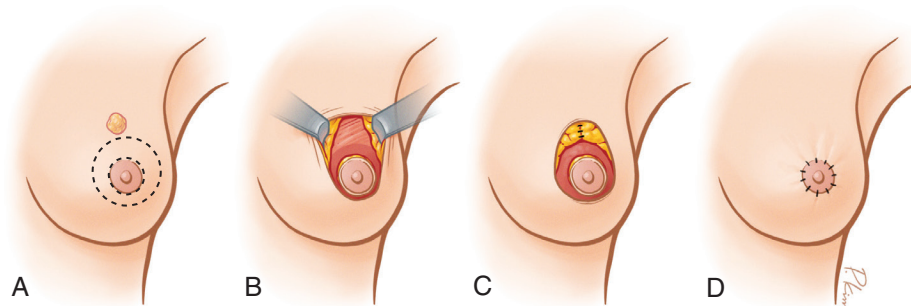
• **Fig. 16.5** Illustration of a local tissue rearrangement performed with local glandular flaps. (A) Preoperative design with parallelogram incision located on the upper-lateral quadrant of the left breast. (B) Breast defect after the upper-lateral lumpectomy. (C) Glandular flaps advancement and final result following primary closure. (Reprinted from Munhoz AM, Montag E, Gemperli R. Oncoplastic breast surgery: indications, techniques and perspectives. *Gland Surg*. 2013;2(3):143–157.)

stitch technique using a conventional purse-string approach. In a second stage after radiotherapy, the total NAC reconstruction with local flaps and tattoo can be performed.

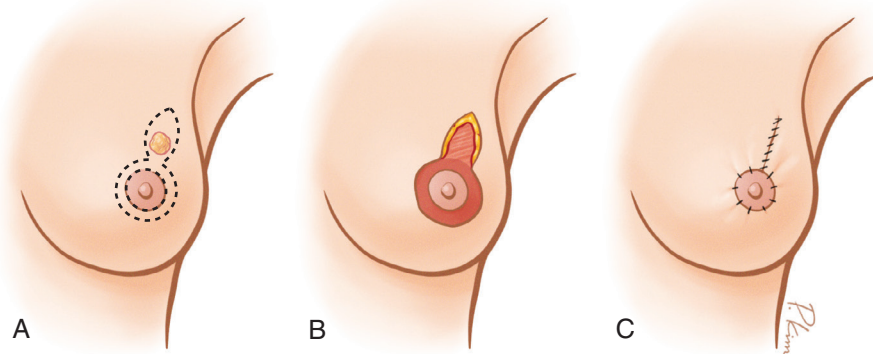
In the situation where the tumor is located close to the NAC (less than 5 cm in small and medium-volume breasts), the conventional round-block technique associated with NAC preservation can be indicated. For this objective, two circular skin markings around the NAC are planned. The inner marking is made on the areolar border and the external marking of the border varies according to the tumor size and location, and the degree of ptosis. After the incisions, the tissue between the two incisions is de-epithelialized. At this point, care must be taken to preserve blood supply to the NAC based on the superior, lateral, medial or inferior pedicles. Following skin undermining around the tumor, lumpectomy is performed including the tumor and surgical margins. The remaining breast tissue

undergoes undermining and approximation and the two periareolar skin incisions are closed using a running suture technique. If necessary, the contralateral NAC may be repositioned using the same technique to improve the breast symmetry (Fig. 16.6; see also Case 16.2.1).

In the situation where the tumor is located close to the NAC and a larger resection is necessary due to the size of the tumor or compromised margins, the round-block technique associated with an incision over the tumor can be indicated. Similar to the tennis racket approach used in nipple-sparing mastectomies, this combined approach uses the total periareolar approach associated with a wedge-shaped incision from the external circular line. Following the BCS, the remaining glandular tissues outside the wedge are brought together, the defects are filled with sutures, and the NAC is repositioned (Fig. 16.7; see also Case 16.3.1).



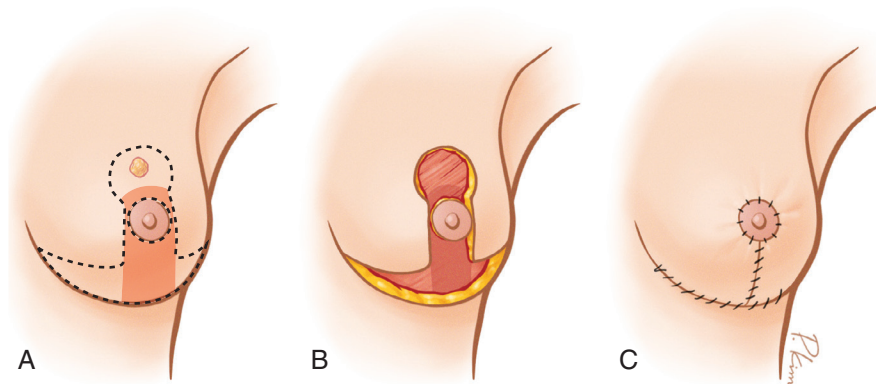
• **Fig. 16.6** Illustration of a local tissue rearrangement performed after an upper lumpectomy without NAC resection and reconstruction with local glandular flaps and round-block technique. (A) Preoperative design with incision located on the upper quadrant of the left breast and including the total periareolar area. (B) Breast defect after the upper lumpectomy. (C) Glandular flap advancement and final result (D) following primary closure through round-block technique. (Adapted from Yang JD, et al. Surgical techniques for personalized oncoplastic surgery in breast cancer patients with small- to moderate-sized breasts (part 1): volume displacement. *J Breast Cancer*. 2012;15(1):1–6.)



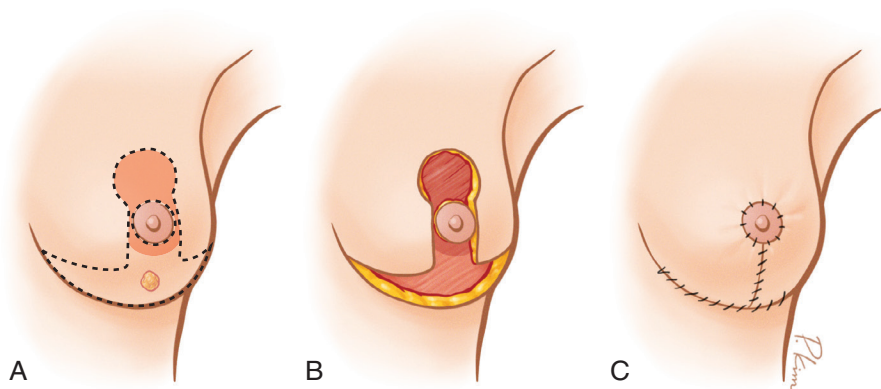
• **Fig. 16.7** Illustration of a local tissue rearrangement performed after an upper-lateral lumpectomy without NAC resection and reconstruction with local glandular flaps and round-block technique. (A) Preoperative design with incision located on the upper-lateral quadrant of the left breast and including the total periareolar area and an incision over the tumor. (B) Breast defect after the upper-lateral lumpectomy. (C) Glandular flap advancement and final result following primary closure through round-block technique. (Adapted from Yang JD, et al. Surgical techniques for personalized oncoplastic surgery in breast cancer patients with small- to moderate-sized breasts (part 1): volume displacement. *J Breast Cancer*. 2012;15(1):1–6.)

Other techniques include the use of mastopexy procedures, which may be used to fill small/medium defects in medium-volume breasts, or even reduction mammoplasty procedures for patients with large breasts.^{4,6-8} The main indication for these techniques is the presence of some remaining tissue available for performing the reconstruction.⁴ In large breasts (cup size D), a number of mammoplasty techniques have

been developed to allow BCS reconstruction using a variety of procedures. Because of rich breast tissue vascularization, the majority of mammoplasty approaches base their planning on preserving the pedicle of the NAC after tumor removal.⁶⁻⁸ These techniques lead to a loss in breast volume, and contralateral breast reduction/mastopexy is frequently necessary to achieve a satisfactory outcome⁸ (Figs. 16.8 & 16.9).



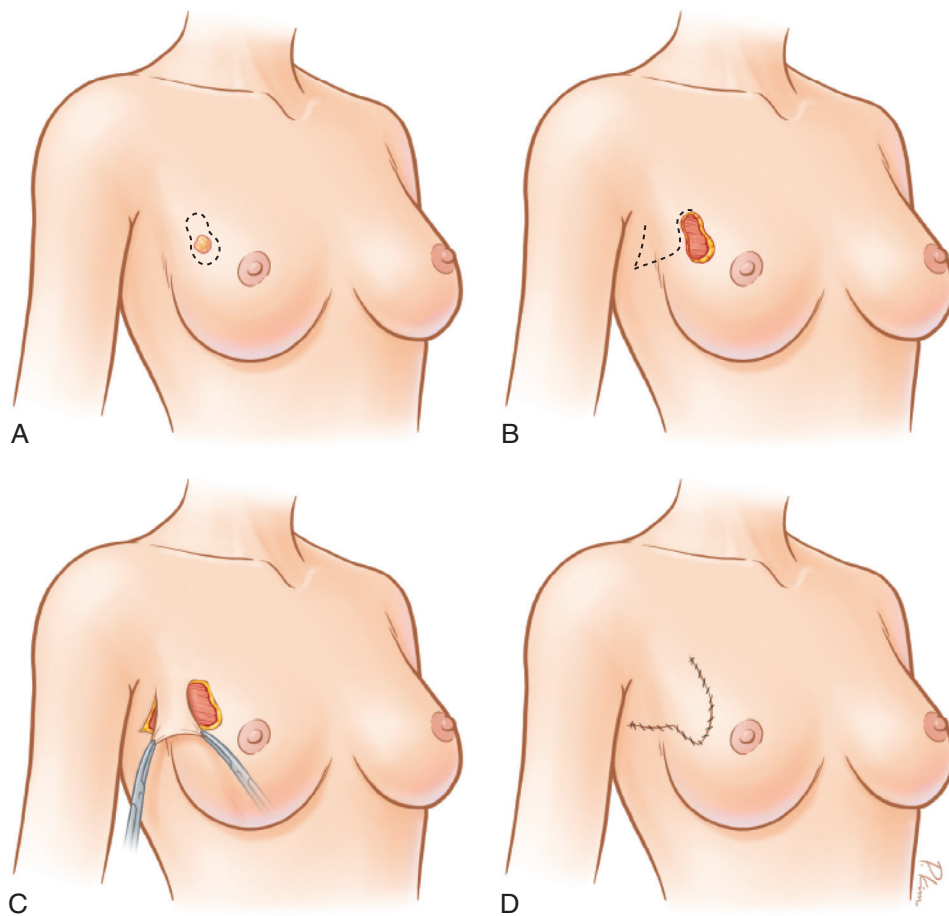
• **Fig. 16.8** Illustration of a local tissue rearrangement performed after an upper lumpectomy without NAC resection and reconstruction with local glandular flaps and reduction mammoplasty with inferiorly based pedicle. (A) Preoperative design with incision located on the upper quadrant of the left breast and including the total periareolar area and an incision over the tumor. (B) Breast defect after the upper lumpectomy. (C) Glandular flap advancement; transposition of the pedicle into the new location and final result following inferiorly based pedicle reduction mammoplasty. (Adapted from Yang JD, et al. Surgical techniques for personalized oncoplastic surgery in breast cancer patients with small- to moderate-sized breasts (part 1): volume displacement. *J Breast Cancer*. 2012;15(1):1-6.)



• **Fig. 16.9** Illustration of a local tissue rearrangement performed after an inferior lumpectomy without NAC resection and reconstruction with local glandular flaps and reduction mammoplasty with superiorly based pedicle. (A) Preoperative design with incision located on the inferior quadrant of the left breast and including the total periareolar area and an incision over the tumor. (B) Breast defect after the inferior lumpectomy. (C) Glandular flap advancement; transposition of the pedicle into the new location and final result following superiorly based pedicle reduction mammoplasty. (Adapted from Yang JD, et al. Surgical techniques for personalized oncoplastic surgery in breast cancer patients with small- to moderate-sized breasts (part 1): volume displacement. *J Breast Cancer*. 2012;15(1):1-6.)

In some situations, local breast tissue is insufficient to fill the BCS defect and volume replacement procedures are better indicated. Volume replacement techniques are defined when the resection defect is reconstructed by replacing the volume of tissue removed with a similar volume of tissue from an extramammary region. This restores the breast volume and avoids the need for contralateral surgery to achieve symmetry. Thus, the main indication for local flaps is the absence of some remaining breast tissue and in

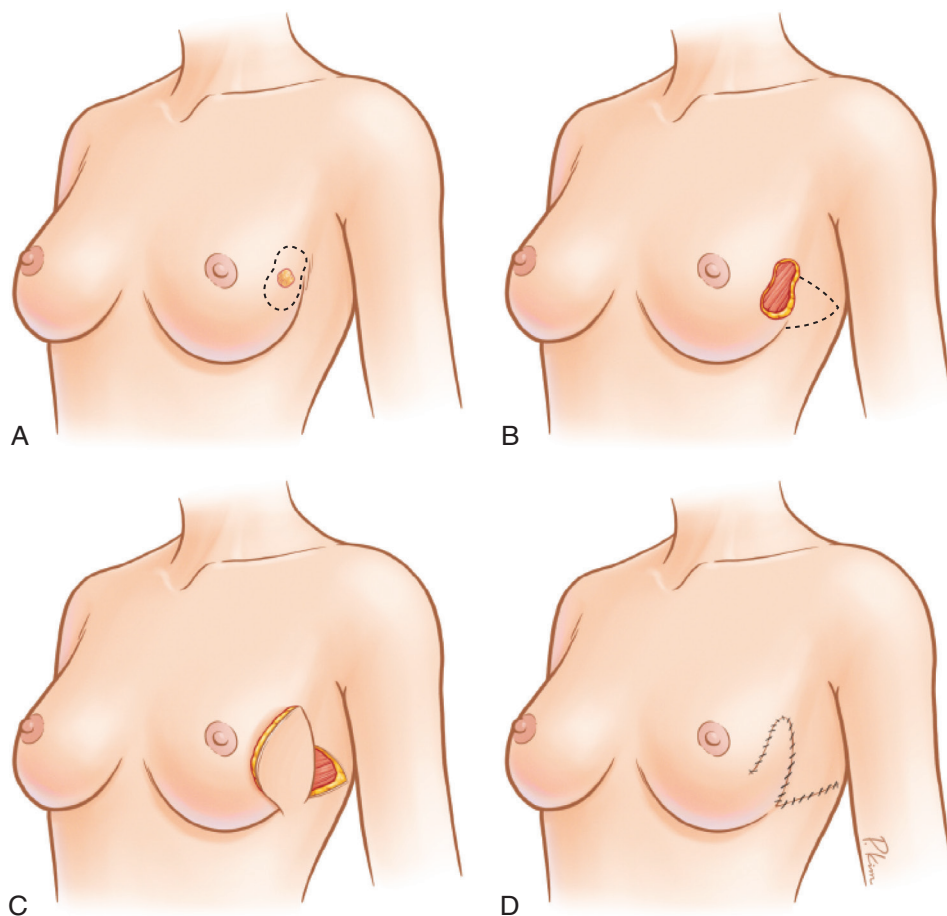
patients with small-volume breasts with/without ptosis. It includes patients with moderate lateral defects where there is not enough breast tissue to perform the reconstruction by LTR based on local glandular flaps or reduction mammaplasty techniques. Fundamentally, volume replacement techniques are represented by rhomboid flaps,^{9,15} lateral thoracodorsal flaps^{5,11–13} and subaxillary flaps,¹⁰ and all these techniques involve the use of excess skin and fat in the lateral thoracic region (Figs. 16.1 & 16.10). When a large local flap



• **Fig. 16.10** Illustration of a local tissue rearrangement performed after left lateral-inferior lumpectomy without NAC resection and reconstruction with lateral thoracodorsal flap. (A) Preoperative design with incision located on the lateral-inferior quadrant of the left breast. (B) Breast defect after the lateral-inferior lumpectomy. (C) Lateral thoracodorsal flap rotation into the lateral breast defect; and final result following flap inset (D).

is necessary, a modification of the lateral thoracodorsal flap can be planned to harvest a flap carrying a large amount of skin and fat tissue.⁵ For this purpose, a convex flap design provides a large amount of skin and makes the base narrower to avoid wound tension closure. Normally, lateral thoracodorsal flap reconstruction is most appropriate for patients

with small or medium-sized breasts with large defects, who are not good candidates for LTR procedures. Other volume replacement techniques such as the subaxillary flap^{9,10,15} and the rhomboid flap¹⁵ are better indicated when replacing less extensive BCS defects (Figs. 16.10 & 16.11; see also Case 16.4.1).



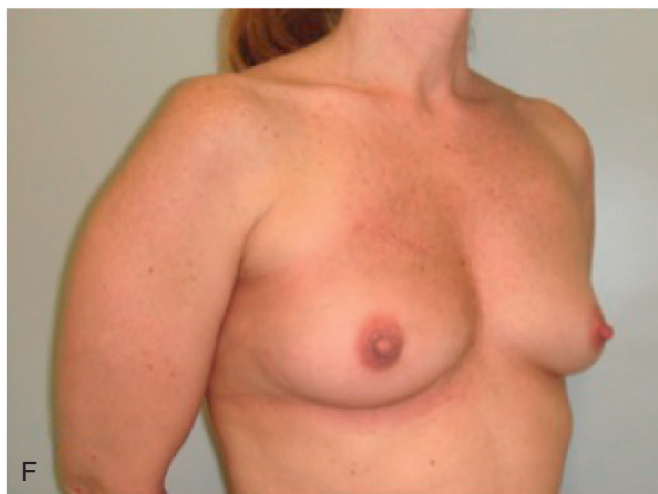
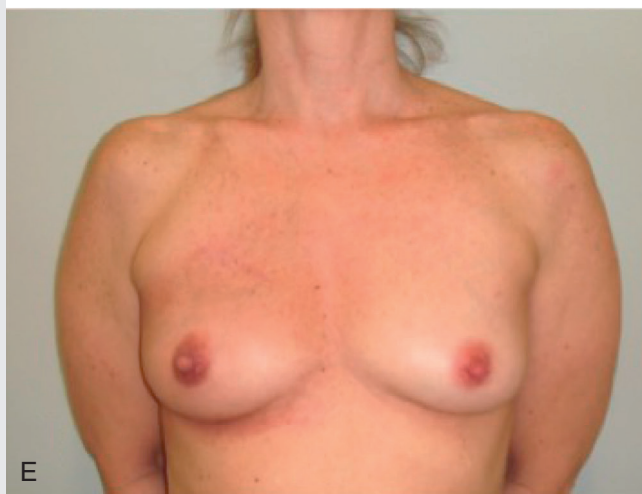
• **Fig. 16.11** Illustration of a local tissue rearrangement performed after right lateral lumpectomy without NAC resection and reconstruction with subaxillary flap. (A) Preoperative design with incision located on the superior quadrant of the right breast. (B) Breast defect after the upper-lateral lumpectomy. (C) Subaxillary flap advancement into the upper lateral breast defect; and final result following flap inset (D).

Case Examples

CASE 16.1

A 51-year-old patient with invasive ductal carcinoma of the right breast, upper quadrant (0.9 cm) (Case 16.1.1A,B). The patient underwent a right superior lumpectomy and sentinel lymph node biopsy, immediately followed by a local tissue

rearrangement with local glandular flaps; a total of 45 g was removed from the right breast (Case 16.1.1C,D). Case 16.1.1E,F shows the one-year postoperative appearance, with a very good outcome after radiation therapy.

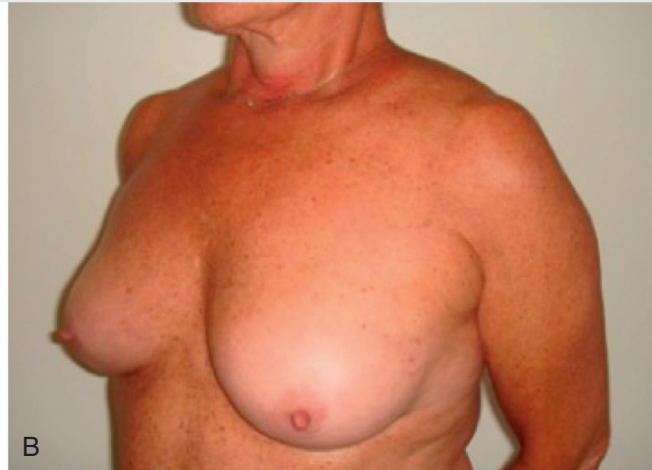


• Case 16.1.1

CASE 16.2

A 55-year-old patient with invasive ductal carcinoma of the left breast, upper-lateral quadrant (1.9 cm) (Case 16.2.1A,B). The patient underwent a left superior-lateral quadrantectomy through total periareolar approach and sentinel lymph node biopsy, immediately followed by a local tissue rearrangement

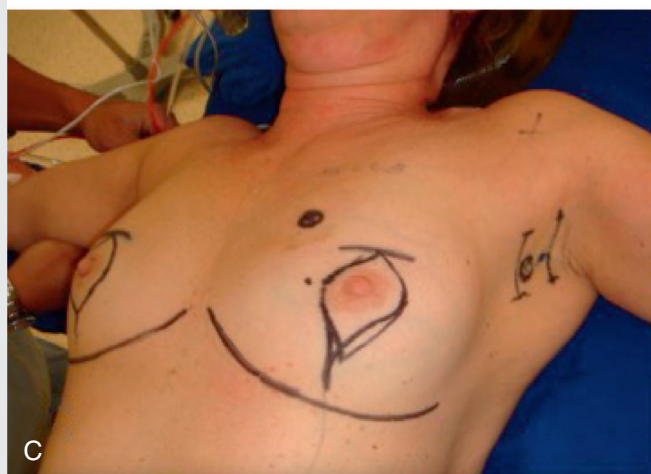
with local glandular flaps and round-block technique; a total of 105 g was removed from the left breast (Case 16.2.1C,D). Case 16.2.1E,F shows the one-year postoperative appearance, with a very good outcome after radiation therapy.



CASE 16.3

A 45-year-old patient with invasive ductal carcinoma of the left breast, upper-medial quadrant (1.3 cm) (Case 16.3.1A,B). The patient underwent a left superior-medial lumpectomy through total periareolar approach associated with an incision over the tumor and sentinel lymph node biopsy, immediately followed

by a local tissue rearrangement with local glandular flaps and round-block technique; a total of 85 g was removed from the left breast (Case 16.3.1C,D). Case 16.3.1E,F shows the appearance four months postoperatively, with a very good outcome after radiation therapy.

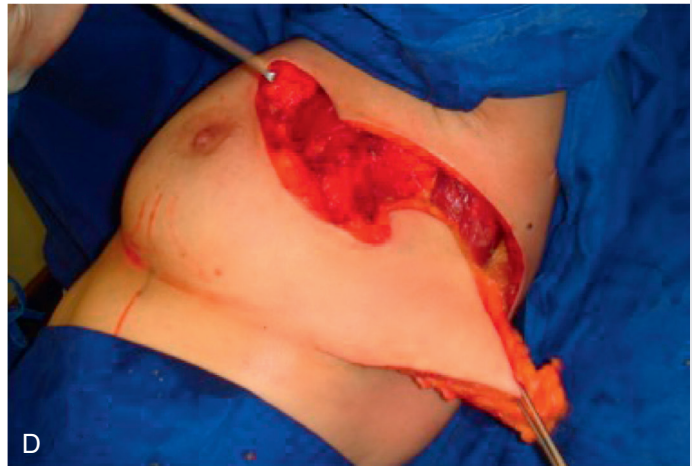


• Case 16.3.1

CASE 16.4

A 57-year-old patient with invasive ductal carcinoma of the left breast, upper-lateral quadrant (3.9 cm) (Case 16.4.1A,B). The patient underwent a left superior-lateral quadrantectomy and sentinel lymph node biopsy, immediately followed by a local

tissue rearrangement with lateral thoracodorsal flap; a total of 165 g was removed from the left breast (Case 16.4.1C,D). Case 16.4.1E,F shows the one-year postoperative appearance, with a very good outcome after radiation therapy.



• Case 16.4.1

Postoperative Care and Expected Outcomes

Two suction drains are left in place and a gauze dressing is used to cover the incisions, and a surgical brassiere is put on. There is no need to change dressings, as the dressing is occlusive; therefore, the patient can shower the day after surgery. Patients are discharged from the hospital on the day of the surgery and are instructed to wear a sports bra night and day for 1 month. Drains are removed after 3–5 days. At 4–7 days postoperatively, the patient is seen in the office, where dressings are changed. The patient is seen again at 6 weeks, 6 months, and 1 year to document the progress of the result, especially during the radiotherapy period.

Management of Complications

The LTR techniques are simple and consistent procedures. In our previous experience, most complications were predictable and did not extend hospital stay or interfere with the adjuvant treatment. Most of complications occur in the initial postoperative period, and when we utilized a local advancement flap the donor site complications were considerably higher than flap complications. Flap complications can occur, are rare and were mainly represented by small partial flap loss and fat necrosis. For this reason, care must be taken in high-risk patients such as smokers and patients with co-morbid associated diseases. Additionally, it is practical to evaluate dermal bleeding in the tip of the flap and shorten it if necessary to avoid partial flap loss. Most local flaps are closed under the minimal degree of tension, and this tension can be distributed along the flap's length. Areas of maximal tension are subject to widening and depression along the line of tension. Trapdoor deformities may occur and may be associated with insufficient incision of wound edges, incomplete undermining, or postoperative scar thickening. Flap failure is infrequent. However, partial necrosis of the distal tip of the flap can occur if the flap angle is excessively acute.¹⁵

Secondary Procedures

All patients should be followed in the postoperative period by the breast surgeon who indicated the best surveillance method. Normally a physical examination and mammography should be performed 6–8 months postoperatively. Physical examination usually demonstrates mild thickening or areas of fibrosis near the LTR margins and the residual breast tissue tending to stabilize by 6 months to 1 year following BCS. Prolonged skin-thickening, increased density, a spiculated mass and fine calcifications that vary in size and shape should be carefully investigated, especially if these alterations develop in different quadrants from the initial tumor and a few years after the BCS.² In situations where it is not possible to distinguish postsurgical changes and local recurrences, MRI should be indicated. In cases where

imaging examinations demonstrate some suspicious lesions, a core biopsy should be performed to evaluate a potential recurrence.⁴ For less desirable cosmetic outcomes after oncoplastic partial breast reconstruction, revisions can be performed accordingly, depending on the nature of the problem, to improve the final result.

Conclusion

With adequate patient selection and several technical aspects, LTR reconstruction following BCS can be performed safely and effectively with a satisfactory outcome and long-term aesthetic result. The overall complications of this type of reconstruction are infrequent, predictable and do not extend hospital stay or interfere with the adjuvant treatment. Operative planning should include the initial breast volume, the presence of breast ptosis and the extent of glandular tissue resected, addressing individual reconstructive requirements. The success of the procedure depends on patient selection, coordinated planning with the oncological surgeon and careful intraoperative management.

PEARLS FOR SUCCESS

- Proper patient selection is crucial for local tissue rearrangement as a reconstruction.
- Alternatives for BCS reconstruction should be undertaken in a multidisciplinary scenario.
- Care must be taken in high-risk patients (smokers and patients with co-morbid diseases).
- Coordinated planning with the oncological surgeon and careful intraoperative management can be critical.
- In some cases, surgery of the contralateral breast may be necessary to improve symmetry.

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17

Partial Breast Reconstruction With Oncoplastic Techniques

ABHISHEK CHATTERJEE AND ALBERT LOSKEN

Introduction

Partial breast reconstruction using large volume displacement oncoplastic techniques has become an important part of reconstructive practice. As an option for women with breast cancer who undergo breast conservation therapy (BCT), this approach has many proven benefits. In some well-selected patients it improves upon standard lumpectomy alone and in others it has advantages over skin-sparing mastectomy and reconstruction.^{1,2}

The term oncoplastic combines cancer surgery and reconstruction, with the two main reconstructive techniques being volume replacement and volume displacement.^{3,3a} The specific reference to large volume displacement oncoplastic surgery implies reduction or mastopexy techniques used in breast cancer patients with moderate- to large-sized breasts. Such oncoplastic designs include large partial mastectomy resections and involve reconstruction with mastopexy or reduction mammoplasty designs to reconstruct the large volume defects with contralateral symmetry breast mastopexy or reduction mammoplasty operations. The goals of the oncoplastic approach are to avoid the BCT deformity, minimize positive margins, broaden indications for BCT, avoid full mastectomy and preserve shape.

Oncoplastic surgery expands the indications for breast conservation allowing the resection of much larger tumors relative to breast size, tumors larger than 4 cm, locally advanced cancers, and prior neoadjuvant chemotherapy that would otherwise only be treated with mastectomy.⁴ Partial reconstruction prior to radiation therapy will minimize the number BCT deformities and improve breast shape.⁵ Compared to partial mastectomy alone, there is less deformity long term especially after radiation with regards to possible nipple eversion volume loss deformity and breast asymmetry. Compared to simple mastectomy with reconstruction, the large volume displacement oncoplastic approach has similar locoregional recurrence and overall survival rates,⁶ preserves better skin and nipple sensation, is aesthetically

better according to validated patient self-assessment tools,⁷ and has been shown to result in lower complication rates and without potential donor-site morbidity.⁸

Indications

The various indications for large volume displacement oncoplastic surgery are listed in [Table 17.1](#). Women with central or lower quadrant tumors have also been shown to have a worse cosmetic outcome because of tumor location, especially when a significant amount of skin is removed. Lower quadrant partial mastectomies have been shown to reduce cosmesis by 50% when compared to other quadrants. The tumor to breast ratio is one of the most important factors when predicting the potential for a poor outcome. In general, when more than 20% of the breast is excised with partial mastectomy, the cosmetic result is likely to be unfavorable.⁸ A recent study of 350 patients demonstrated that the maximal volume of tissue resected with lumpectomy without resulting in unacceptable aesthetic and functional outcomes of decreased quality of life (QOL) were 18%–19% in the upper outer quadrant, 14%–15% in the lower quadrant, 8%–9% in the upper-inner quadrant and 9%–10% in the lower inner quadrant.⁹

Contraindications to the immediate oncoplastic technique include those patients not candidates for breast conservation surgery (BCS), prior history of chest wall irradiation, diffuse multicentric breast disease, inflammatory breast cancer and those patients without sufficient breast tissue remaining to warrant BCS.

Preoperative Evaluation and Special Considerations

When indicated, it is better to perform oncoplastic techniques immediately at the time of tumor resection.¹⁰ This is often preferred since it is only one procedure and has the

TABLE 17.1 General Indications for Oncoplastic Surgery

Cosmetic Reasons	Oncological Reasons
High tumor to breast ratio (>20%)	Concern about clear margins
Tumor location – central, inferior, medial	Wide excision required
Macromastia	Poor candidate for mastectomy and reconstruction (i.e., age, breast size)
Large tumor	Patient desires breast conservation
Patient desires smaller breasts	
Significant ptosis, or breast asymmetry	

benefits of operating on a non-irradiated breast. Reduction techniques prior to radiation therapy result in a significantly lower complication rate when compared to performing reductions after completion of radiation therapy.¹¹ If margins are a major concern, the delayed immediate approach can be performed, where partial breast reconstruction is delayed until confirmation of negative margins and before radiation therapy. When a BCT deformity exist, the partial reconstruction can be performed in a delayed fashion. Since the delayed approach requires operating on an irradiated breast, this often has higher postoperative complications, increased need for flap reconstruction and poorer aesthetic outcomes.¹⁰

The breast reshaping oncoplastic procedures all essentially rely on advancement, rotation or transposition of a large area of breast using mastopexy or reduction techniques to fill a moderate- to large-sized defect. This absorbs the volume loss over a larger area. The most common large volume displacement techniques are shown in Table 17.2.

The ideal patient is one where the tumor can be excised within the expected breast reduction specimen, in medium to large or ptotic breasts where sufficient breast parenchyma remains following resection to reshape the mound. Past descriptions for oncoplastic operations have included: (1) planning skin incisions and parenchymal excisions following reduction/mastopexy templates; (2) parenchymal reshaping following excision; (3) repositioning the nipple; and (4) correction of the contralateral breast for symmetry.¹² Any moderate to large breast can be reconstructed using these techniques unless a skin deformity exists beyond the standard Wise pattern. Plastic surgeons are all familiar with these techniques, making the incorporation of this approach into their reconstructive practice an easy addition. Using the new ASBrS/SSO/ASTRO margin guidelines,^{13,14} as long as a breast cancer can be removed with adequate margins

TABLE 17.2 Large Volume Displacement Oncoplastic Techniques

Skin Incision Pattern	Pedicle Blood Supply to NAC	Tumor Location in Breast
Circumvertical	Superior	Inferior pole
Inverted T	Superomedial	LIQ, LOQ, UOQ
Inverted T	Inferior	LIQ, LOQ, UOQ, UIQ
Inverted T	Free nipple graft	Central

LIQ, lower inner quadrant; LOQ, lower outer quadrant; UOQ, upper outer quadrant; UIQ, upper inner quadrant; NAC, nipple–areola complex.

(no tumor on ink for invasive cancer, and at least a 2-mm margin for ductal carcinoma *in situ*) and the overlying skin is not diseased, taking the overlying skin is not necessary. Therefore, using standard skin incision patterns such as the circumvertical or inverted T skin patterns and planning a pedicle away from the cancer site can allow for easy access to the cancer site. Specific steps in skin incision design are described in the cases below.

Surgical Techniques

Once the resection is performed (see Case 17.1.6), the cavity is inspected paying attention to the defect location in relation to the nipple, as well as the remaining breast tissue. Clips should be placed either by the breast or plastic surgeon at the borders of the lumpectomy defect (at least 6 clips). The reconstructive goals include: (1) preservation of nipple viability; (2) closure of the defect space; and (3) reshaping of the breast mound. If the partial mastectomy resection is close to the nipple–areola complex, the obliteration of dead space is important to reduce the nipple inversion complication especially from the scarring post-radiation.¹⁵ The nipple and dermatoglandular pedicle is dissected (Case 17.1.8), and remaining tissue is resected if necessary for completion of the reduction. The contralateral procedure is performed using a similar technique. The ipsilateral side is typically kept about 10% larger to allow for radiation fibrosis.

Larger, more remote defects and defects in smaller breasts can be reconstructed using autoaugmentation flaps during oncoplastic reduction or mastopexy procedures (see Case 17.1). Autoaugmentation options include extending the primary pedicle to rotate into a defect or creating a secondary dermatoglandular pedicle to move independent to the nipple pedicle and fill a defect (Case 17.1.9).¹⁶

Case Examples

CASE 17.1

Inverted T Skin Incision, (Extended) Superomedial Pedicle Oncoplastic Design for an Upper Outer Quadrant Tumor

This is a 48-year-old female with large breasts with grade 2 ptosis (Cases 17.1.1 & 17.1.2). Her cancer was located in the upper outer quadrant and was large even after neoadjuvant chemotherapy. The plan was to perform an extended superomedial pedicle (winged), inverted T skin incision oncoplastic reconstruction rotating the lower outer quadrant tissue into the upper outer quadrant defect after the cancer had been removed (Cases 17.1.3–17.1.5). The upper outer quadrant access for the breast surgeon was facilitated using the inverted T incision that allowed the surgeon to remove the necessary large region (Case 17.1.6). The partial mastectomy specimen was larger than 15 cm (Case 17.1.7). The extended superomedial pedicle (winged) specimen was de-epithelialized

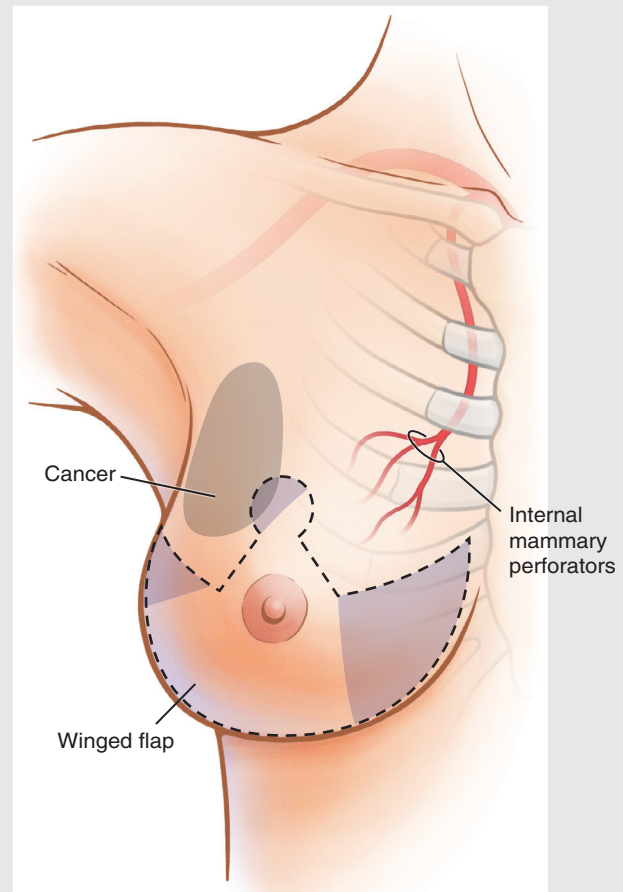
with perfusion noted at the tip of the pedicle region in the lower outer quadrant showing punctate bright red bleeding (Case 17.1.8). Autoaugmentation of the large upper outer quadrant defect was performed by tucking the extended superomedial pedicle into the upper outer quadrant and securing it in place with two or three absorbable sutures (Case 17.1.9). The lateral and medial pillars were then brought in centrally as one would do in an inverted T incision closure pattern (Case 17.1.10). A symmetry reduction was performed on the contralateral side (Case 17.1.11). Pre- (Case 17.1.11) and postoperative (Case 17.1.12) comparison photographs even after radiation note good symmetry and aesthetic form.



• Case 17.1.1



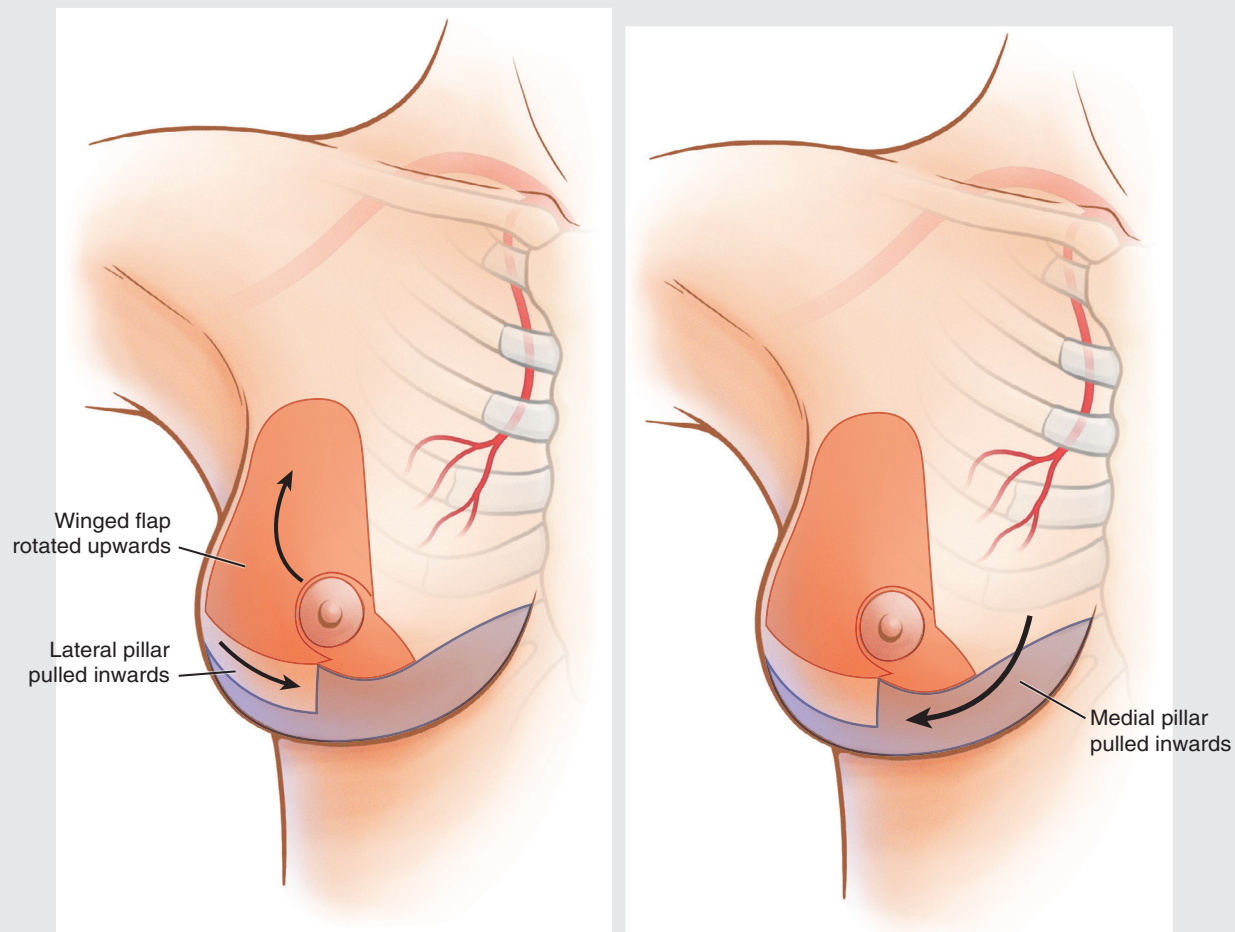
• Case 17.1.2



• Case 17.1.3

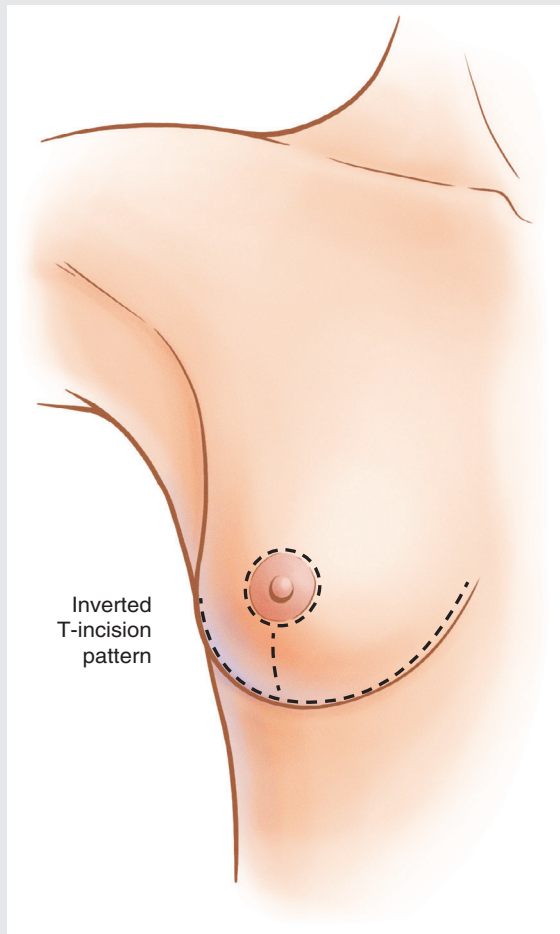
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CASE 17.1—cont'd

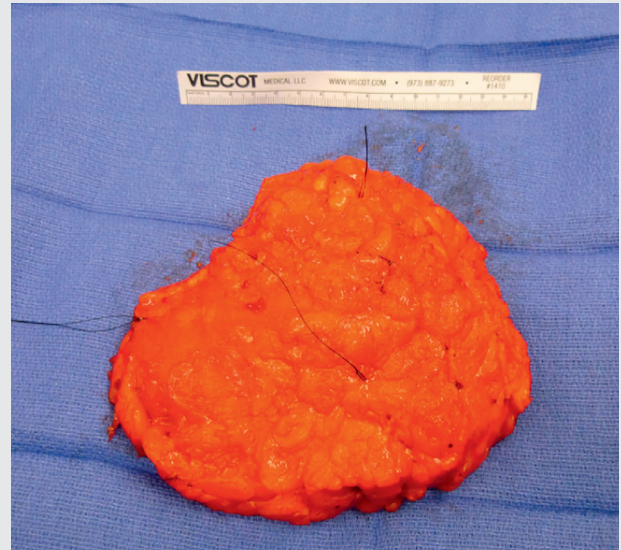


• Case 17.1.4

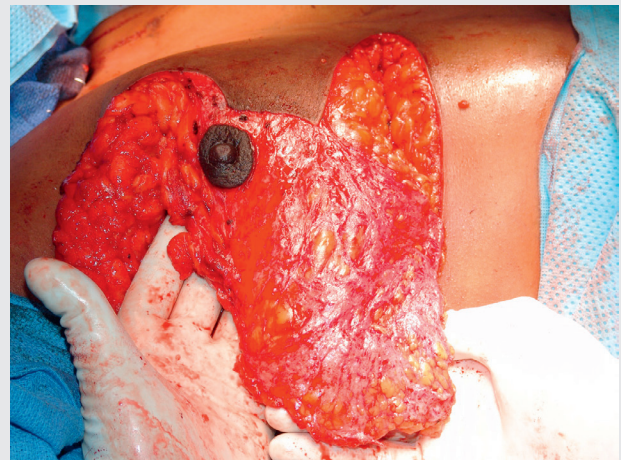
CASE 17.1—cont'd



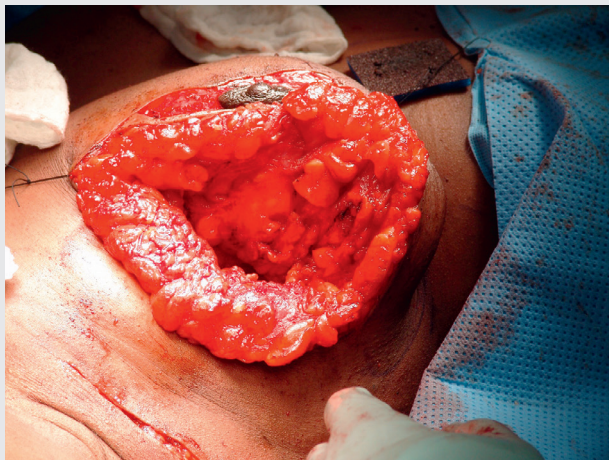
• Case 17.1.5



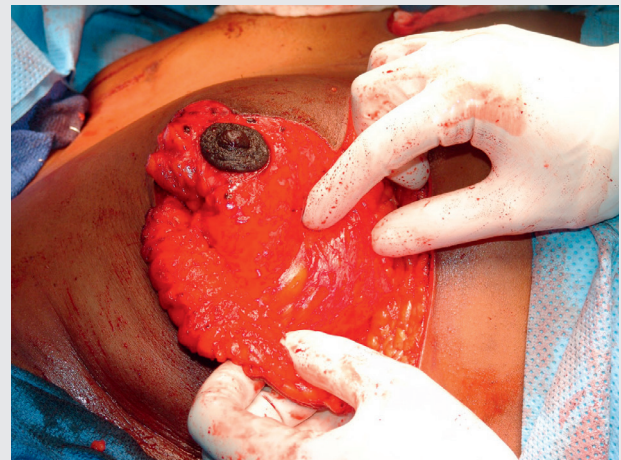
• Case 17.1.7



• Case 17.1.8



• Case 17.1.6



• Case 17.1.9

Continued

CASE 17.1—cont'd



• Case 17.1.10



• Case 17.1.11



• Case 17.1.12

**Key Pearls**

1. Applicable for large upper outer quadrant defects.
2. Applicable for women with moderate- to large-sized breast, grade 2 or 3 ptosis.
3. Not applicable for patients with grade 1 ptosis, women with small breasts.
4. Not applicable for women with cancers located centrally or in the region of the superomedial pedicle (inner

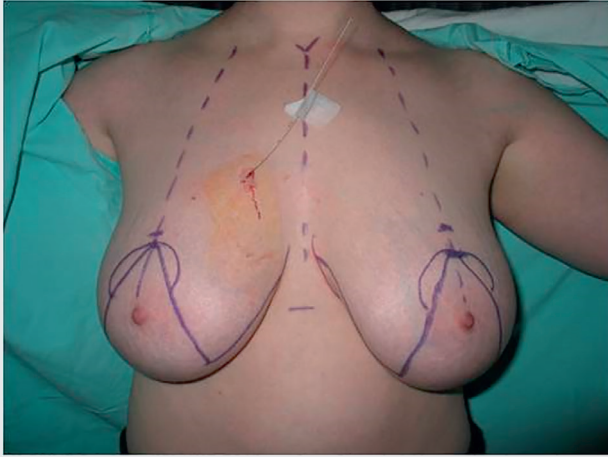
quadrant regions where the internal perforators enter the pedicle).

5. The additional inferior pole of tissue attached to the standard superomedial pedicle defines the "extended superomedial pedicle." Use this to fill in especially large upper outer quadrant defects.

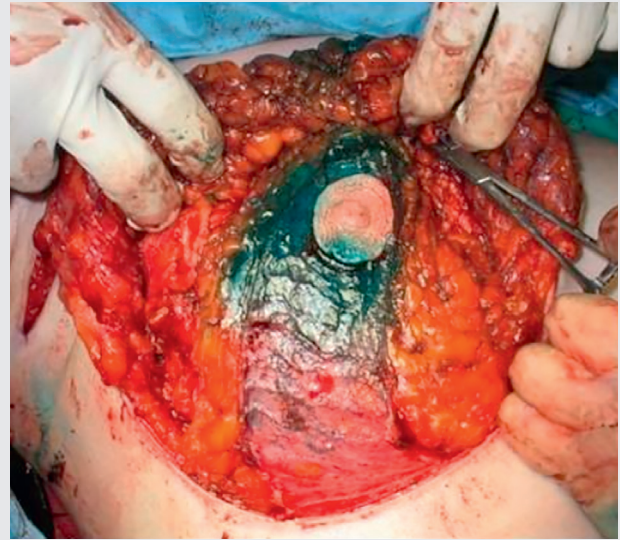
CASE 17.2**Inverted T Skin Incision, Inferior Pedicle Oncoplastic Design for an Upper Inner Quadrant Tumor**

This is a patient with moderate-sized breasts with grade 2 ptosis (Case 17.2.1). She has an upper inner quadrant defect (Case 17.2.2), which is a region particularly difficult to treat with standard breast conservation as it affects the cleavage of the breast form. The inverted T skin incision design with an

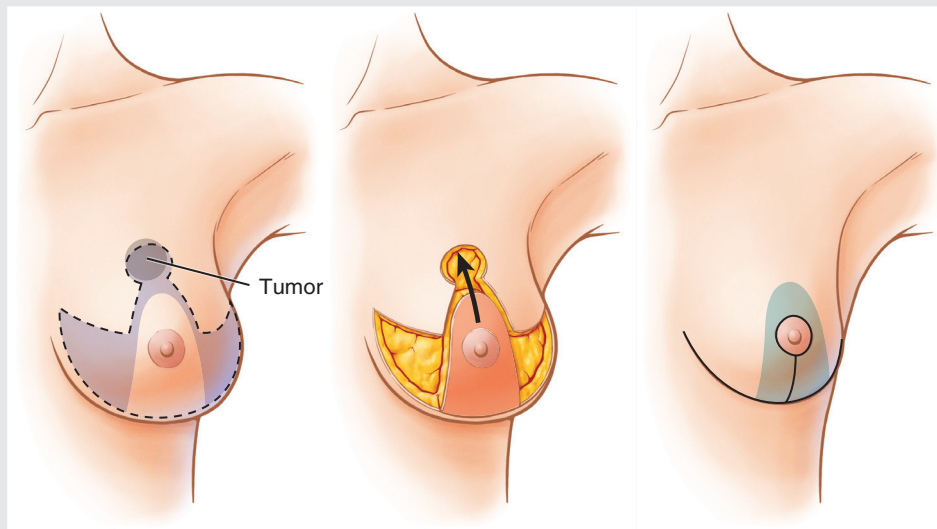
inferior pedicle is particularly helpful here as it can fill in the void created in the upper inner quadrant (Case 17.2.3), especially as the lateral and medial pillars are centralized over the inferior pedicle (Case 17.2.4). Postoperative photos show good symmetry and aesthetic form.



• Case 17.2.1



• Case 17.2.2



• Case 17.2.3

Continued

CASE 17.2—cont'd



• Case 17.2.4

(Case 17.2.4 adapted from Losken A, Hamdi M. *Partial Breast Reconstruction*. New York, NY: Thieme, 2017.)

Key Pearls

1. Applicable for upper outer quadrant, upper inner quadrant, lower outer quadrant and lower inner quadrant defects.
2. Applicable for women with moderate- to large-sized breasts, grade 2 or 3 ptosis.
3. Not applicable for patients with grade 1 ptosis, women with small breasts.
4. Not applicable for women with cancers located centrally or in the region of the inferior pedicle (lower pole of the breast where the intercostal perforator arteries enter the pedicle).

CASE 17.3

Inverted T Skin Incision, Free Nipple Graft Oncoplastic Design for a Central Breast Tumor

This is a 60-year-old female with extensive ductal carcinoma *in situ* (DCIS) in the central region of her breast extending close to but not involving the nipple–areola complex. She has large breasts with grade 3 ptosis (Case 17.3.1). An inverted T skin incision pattern was used with a free nipple graft which was removed as a full-thickness graft using a #10 blade knife (Case 17.3.2). To increase perfusion to the nipple graft, we defatted it

using iris scissors (Case 17.3.3), and created a bolster negative pressure wound dressing with a xeroform barrier (Case 17.3.4). We connected this to a portable negative pressure wound device at negative 125 mmHg. Pre- and postoperative images (Cases 17.3.5–17.3.7) show smaller breasts with improved ptosis.



• Case 17.3.1

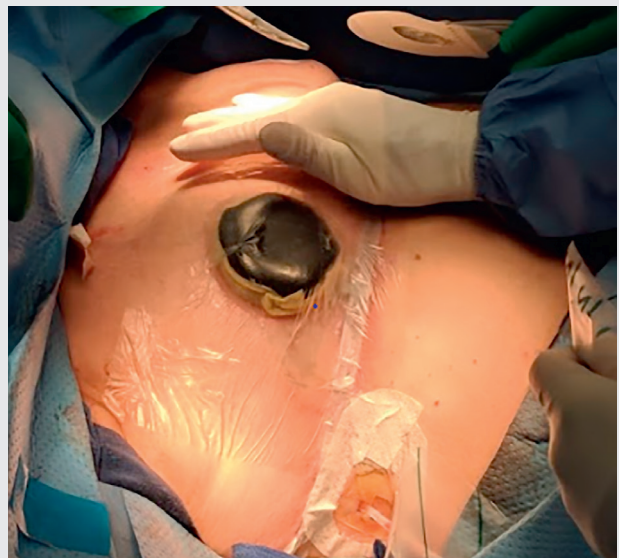


• Case 17.3.2

CASE 17.3—cont'd



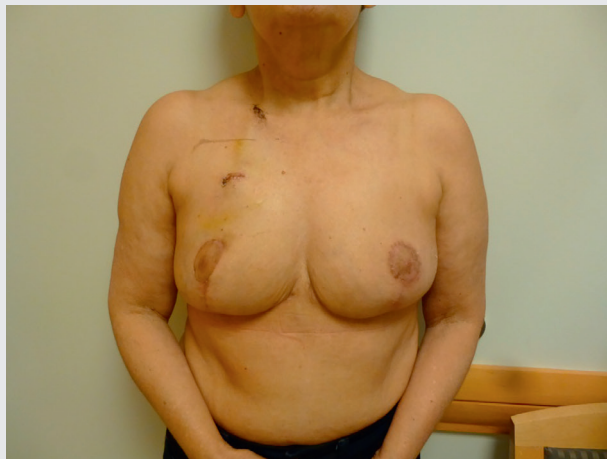
• Case 17.3.3



• Case 17.3.4

Continued

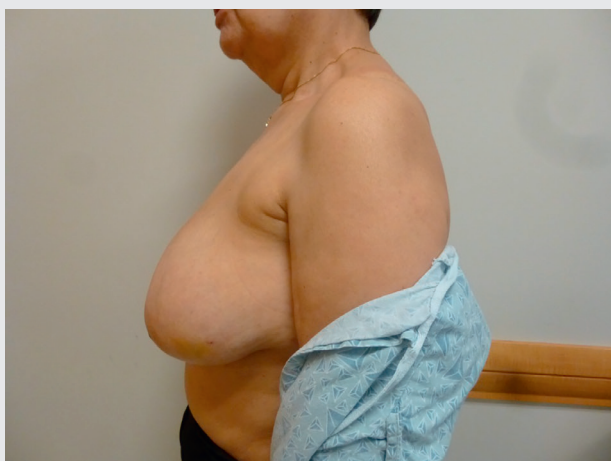
CASE 17.3—cont'd



• Case 17.3.5



• Case 17.3.6



• Case 17.3.7

Key Pearls

1. Applicable for centrally located cancer without involvement of the nipple–areola complex (NAC).
2. Remove nipple–areola complex as a full-thickness skin graft. Use a 42-mm cookie cutter if the NAC is too large preoperatively.
3. Place it at the new NAC position over the de-epithelialized keyhole and bolster it to prevent hematoma/seroma/shearing.

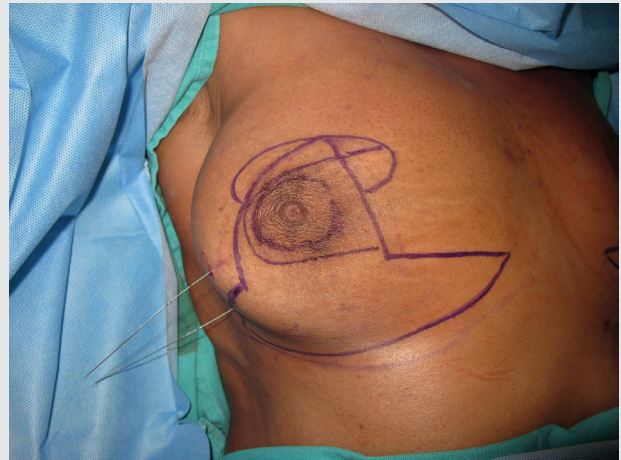
CASE 17.4**Superomedial Pedicle With Lower Outer Quadrant Autoaugmentation Technique for Large Upper Outer Quadrant Defects**

This is a 48-year-old with moderate breast size and ptosis who presented with a right lateral infiltrating ductal carcinoma (Case 17.4.1). She has a large cancer at the 3 o'clock position of her right breast demonstrated by her bracketing wires (Case 17.4.2). After removal, the remaining defect was large (Case 17.4.3), and a standard central mound or inferior pedicle reduction would not have given her sufficient tissue to fill the defect at its high position. A decision was made to use the lower pole breast tissue to create a secondary inferiorly based pedicle to fill the tumor defect. In essence, the superomedial

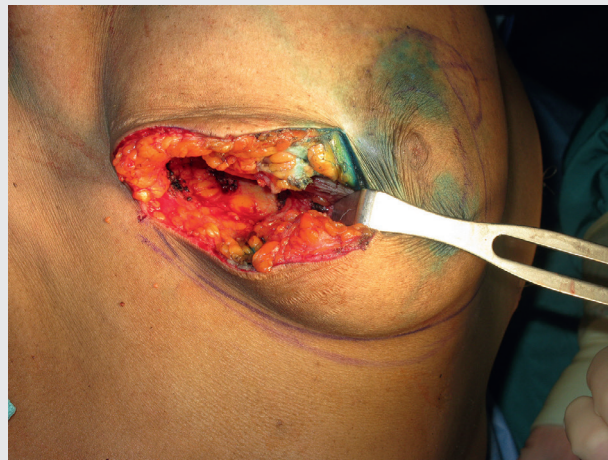
pedicle could fill in a part of the upper outer quadrant defect (Case 17.4.4) and the lateral pillar of skin and thinned out tissue (where the cancer had been) could be brought inferiorly and centrally to cover the de-epithelialized region (Case 17.4.5) of the lower outer quadrant thus completing this method of autoaugmentation.. At one year after radiation therapy, the patient has symmetric breasts after a contralateral symmetry operation was performed and an appropriate elevation of the nipple–areola complex (Case 17.4.6).



• Case 17.4.1



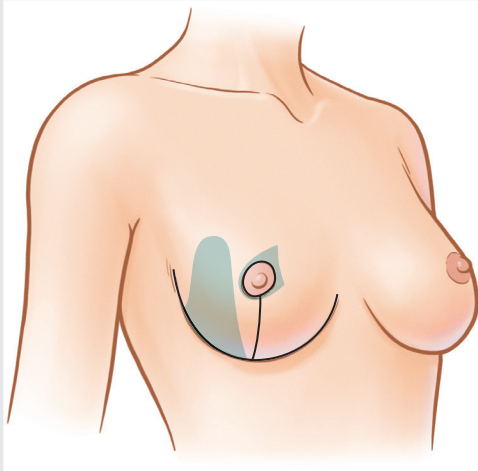
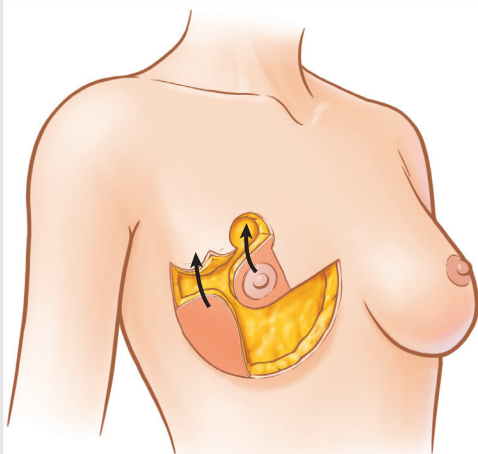
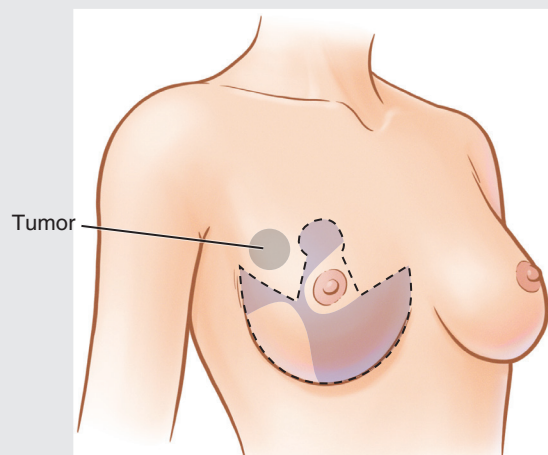
• Case 17.4.2



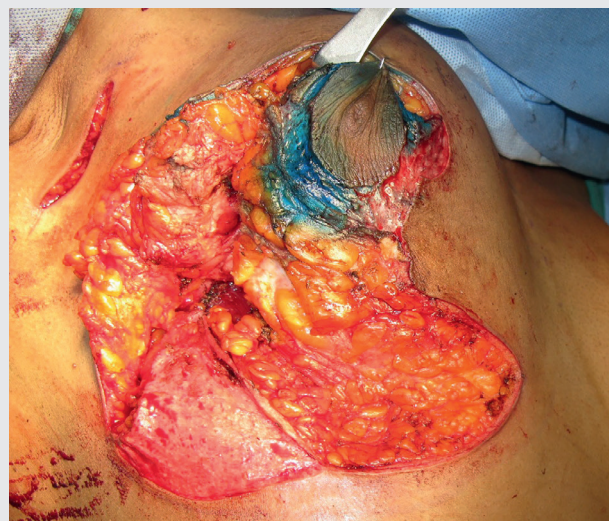
• Case 17.4.3

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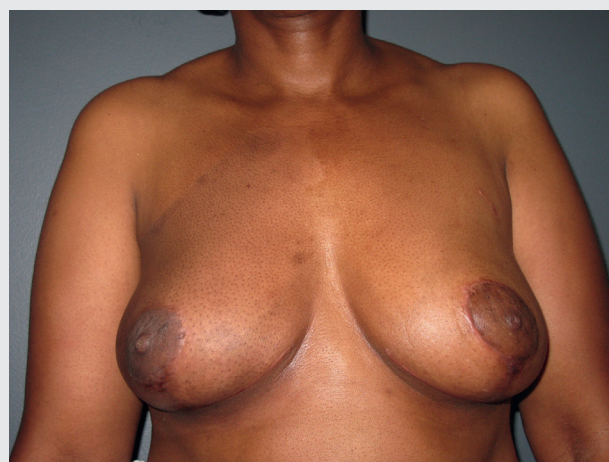
CASE 17.4—cont'd



• Case 17.4.4



• Case 17.4.5



• Case 17.4.6

Key Pearls

1. Applicable for upper outer quadrant defects.
2. Applicable for women with grade 2 or more ptosis and women with larger or moderate-sized breasts.
3. Not applicable for grade 1 ptosis, women with small breasts.
4. Not applicable for women with lower outer quadrant cancers.
5. Not applicable for women with cancers located centrally or in the region of the superomedial pedicle (inner quadrant regions where the internal perforators enter the pedicle).

(Case 17.4.4 adapted from Losken A, Hamdi M. Partial Breast Reconstruction. New York, NY: Thieme, 2017.)

Postoperative Management and Expected Outcome

The importance of negative margins in BCT cannot be overstated and has been associated as a factor for increased local recurrence.^{13,14} Oncological principles should be applied with even greater stringency when reconstructive procedures have been performed since positive margins on final pathology are potentially complicated by altered architecture or elimination of a potential reconstructive option. Positive margins according to the joint guidelines of the American Society of Breast Surgeons/Society of Surgical Oncology/American Society of Radiation Oncology (ASBrS/SSO/ASTRO) constitute no tumor on ink for invasive breast cancer and less than 2 mm margins for ductal carcinoma *in situ*.^{13,14}

One of the strengths of the oncoplastic approach is the ability to resect widely and subsequently obtain a lower positive margin rate at 10% compared to 20%–40% for standard lumpectomy.⁵ This translates to far fewer re-excisions and secondary operations, and occurs because the breast surgical oncologist has the option to remove a greater section of breast tissue since reconstruction would follow. Fewer secondary operations mean that adjuvant treatment in the form of chemotherapy and radiation is not delayed. With the more generous oncoplastic resection, positive margin rates have been shown to be significantly reduced.

If tumor is still present in the second set of biopsies, then a mastectomy is indicated. Placement of titanium perimeter clips to outline the lumpectomy cavity will guide the radiation therapy with postoperative tumor boost volume during teletherapy (external beam radiation).¹⁷ The options if positive margins exist would be discussed by the multidisciplinary team and include re-excision, completion mastectomy or no additional resection if additional resection of the tumor was performed by the reduction mammoplasty and deemed clear histologically. Although re-excision can often be safely performed on a case by case basis,¹⁸ often after a generous oncoplastic resection (>200 g) if positive margins exist, these patients might be better served with completion mastectomy.

Management of Complications

It is important that complications resulting from oncoplastic techniques do not interfere with the initiation of adjuvant therapy.⁵ The authors routinely manage oncoplastic surgery complications with conservative management such as the use of collagenase creams or Silvadene for inverted T junction wound dehiscence. It is only for the rare patient that skin grafting for a significant, non-healing inverted T junction wound is needed. Fat necrosis is routinely monitored without further surgery as patients will get at least an annual mammogram and clinical exam which can also monitor the yearly progression of fat necrosis that typically

is asymptomatic for patients. Infections are rare and also have been treated with a short course of antibiotics with close monitoring.

Secondary Procedures

Complications in oncoplastic surgery are not common. From an oncologic standpoint, a positive margin will likely necessitate either an additional margin excision for which the reconstruction will have to be undone in the acute 2–3 week postoperative period to access the area in need of re-excision or a completion mastectomy will be needed. From a reconstructive standpoint, T-junction dehiscence and associated skin necrosis in this region can most often be treated with antibiotic creams for 1–2 weeks with secondary healing leading to a scar that is rarely noticeable and well hidden in the inframammary crease. Very rarely, the skin necrosis at the T-junction will be significant enough to require a skin graft to aid the healing which most often can be done in a procedure room. Substantial bleeding to the point of operative intervention occurs rarely.

Conclusion

The large volume displacement oncoplastic approach has become increasingly accepted as a safe and reliable alternative option in breast conservation surgery. We are now seeing more evidence demonstrating the various techniques as well as favorable outcomes from an aesthetic and oncological perspective. Patient-reported outcomes are also favorable in how oncoplastic surgery can improve satisfaction and quality of life. It will likely increase in popularity as more breast surgeons and plastic surgeons work together and incorporate this approach into their practice.

PEARLS FOR SUCCESS

- Preoperative discussion with the breast surgeon to assess quadrant of cancer so as to plan the appropriate type of pedicle and skin incision design.
- Preoperative discussion with the patient should set expectations that their breasts will be smaller in addition to being less ptotic after surgery.
- Aim to make the cancer side slightly bigger by 10% compared to the contralateral symmetry side so as to accommodate the shrinkage from postoperative breast radiation. Immediate contralateral symmetry operations should be done whenever possible.
- Use medium clips to mark the boundaries of the lumpectomy site to aid radiation oncology planning. At least 6 clips should be used.
- Inverted T-junction dehiscence will often heal within 2–3 weeks postoperatively with antibiotic ointment and close follow-up.

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18

Symmetry Procedures in Breast Reconstruction

HANI SBITANY AND RACHEL LENTZ

Introduction

Achieving optimal symmetry is the primary goal of unilateral and bilateral breast reconstruction. In cases of unilateral breast reconstruction, which is the focus of this chapter, this often requires a secondary procedure on the ipsilateral breast and/or contralateral breast.^{1,2} It is estimated that up to 70% of women will undergo one or two procedures in an attempt to obtain symmetry.³ The primary operations utilized include augmentation mammoplasty, mastopexy, and reduction mammoplasty. Additionally, autologous fat grafting can further refine and correct contour deformities on both breasts, yielding a more natural and symmetric appearance.

The discussion of the likely need for such a symmetry procedure should occur at time of initial consultation with the patient, when breast reconstruction is discussed. The patient should be informed that both the need and desire for a contralateral symmetry procedure will be high.⁴ Furthermore, the timing of this procedure should also be discussed. In addition to discussing the likely procedures necessary, based on the patient's goal size for the reconstructed breast, the different external scars that may result on both breasts should also be described.

The timing of secondary and symmetrizing operations remains an issue of debate. Proponents of simultaneous contralateral operations argue better aesthetics without an increased complication rate, and a reduction in the number of overall operations. However, opponents contend that immediate postoperative changes in the reconstructed breast, primarily swelling, are often unpredictable, and a more symmetric final result may be achieved by waiting until the reconstructed breast has reached its ultimate size and location on the chest wall prior to matching. Ultimately, either approach is acceptable, as long as the patient understands the benefits of each, and makes an informed decision.

In planning the approach, the plastic surgeon must also account for timing around any adjuvant oncologic treatment being delivered to the patient. If a contralateral operation is not done at the time of the patient's initial reconstruction, it is preferable to delay until the patient has completed any adjuvant chemotherapy or radiation therapy. Because the reconstructed breast will often be operated on simultaneously, for aesthetic enhancement, such an approach will reduce complication rates, and improve symmetry.

Indications and Contraindications

It is the authors' opinion that almost every patient undergoing unilateral breast reconstruction will be a candidate for some form of contralateral breast symmetry procedure. This is offered with the goal of achieving optimal aesthetic outcome. The key is selecting the appropriate procedure in each patient's situation.

For those patients undergoing a large size increase from native to reconstructed breast, then a contralateral augmentation mammoplasty will usually be offered (Fig. 18.1). This is the consistent method used for achieving volume symmetry in these patients. When offering this procedure, the surgeon must ensure the patient has appropriate soft tissue quality to support either a subglandular or submuscular implant placement. Furthermore, if greater than grade 1 ptosis exists on the breast, the need for a simultaneous mastopexy should be discussed.

For those patients in whom a smaller reconstruction volume is achieved, relative to native breast size, a contralateral reduction mammoplasty is offered. The primary techniques considered for reduction include the classic inverted "T" inferior pedicle (Wise pattern), and the vertical pattern with medial or superior-medial pedicle. The Wise pattern reduction is reserved for patients with grade 3 breast ptosis, in need of significant skin resection, and greater than 800 g parenchymal resection. The vertical pattern is used for



• **Fig. 18.1** (A,B) A 38-year-old female with left breast cancer. Patient is seen preoperatively (A), prior to left NSM and two-stage prepectoral prosthetic reconstruction. Patient also required left post-mastectomy radiation therapy. Postoperative photos (B), shown 2.5 years after completion of left breast reconstruction, illustrate the need for symmetry procedures. At this stage, patient has already undergone a right native breast subfascial augmentation for symmetry. However, there remains nipple positional asymmetry, and the patient undergoes a right crescent mastopexy (C) for improvement of symmetry. The patient has also undergone left breast upper pole fat grafting for restoration of volume after mastectomy and radiation. This example highlights the challenge of symmetry and the need, in some cases, for multiple procedures in combination, to attain this.

breasts with grade 2 ptosis, and anticipated parenchymal resection of less than 800 g.⁵ The authors' preference is the vertical pattern, as it results in a breast with greater projection, and longer lasting result, due to the parenchyma reshaping involved; thus, this better matches a reconstructed breast.

In patients requiring correction of nipple–areola complex (NAC) position on the breast, without alteration of breast size, mastopexy is preferred. In the authors' experience, when used for contralateral symmetry in breast reconstruction, mastopexy is often performed in conjunction with another procedure for symmetry on that breast. Most commonly, it accompanies an augmentation mammoplasty, for further correction of NAC height. Alternatively, it can be performed as a component of a reduction mammoplasty, which also elevates the NAC position, in conjunction with size reduction. All patients must undergo careful evaluation of changes in NAC position in the reconstructed breast, when nipple-sparing mastectomy (NSM) is performed, and

allow this to guide the need for contralateral mastopexy. Oftentimes with NSM and prosthetic reconstruction, there is NAC elevation, due to skin and/or muscle contraction.

Autologous fat grafting is promoted by the author for almost all reconstructive patients, given that fat injection carries a multitude of benefits, both aesthetic and restorative. Most commonly, autologous fat grafting is performed on the reconstructed breast, for enhancing upper pole aesthetic symmetry with the native breast. In the reconstructed breast, upper pole parenchyma resection during the mastectomy results in tissue deficit and hollowing, and autologous fat grafting is an ideal correction. On the contralateral breast, fat grafting can similarly restore volume and enhance contour in specific, isolated areas of the breast. Furthermore, autologous fat offers restoration of tissue quality in the breast, due to its high stem cell concentration, and this benefits both breasts.⁶

In all cases, the only absolutely contraindication to contralateral symmetry procedures is active smoking. In

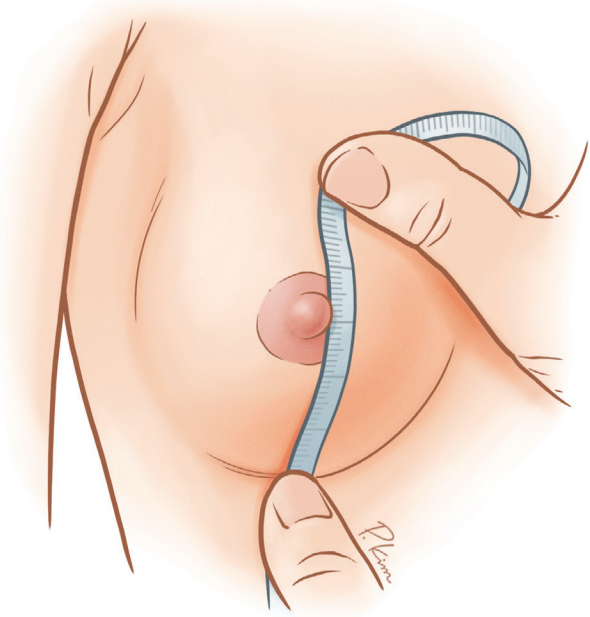
such cases, the elective procedures should be delayed until the patient has quit smoking for a minimum of 6 months. Relative contraindications to these procedures include a contralateral breast with a history of prior radiation therapy, obesity, or a preoperative breast shape/size that makes achieving reasonable symmetry unlikely.

Preoperative Evaluation and Special Considerations

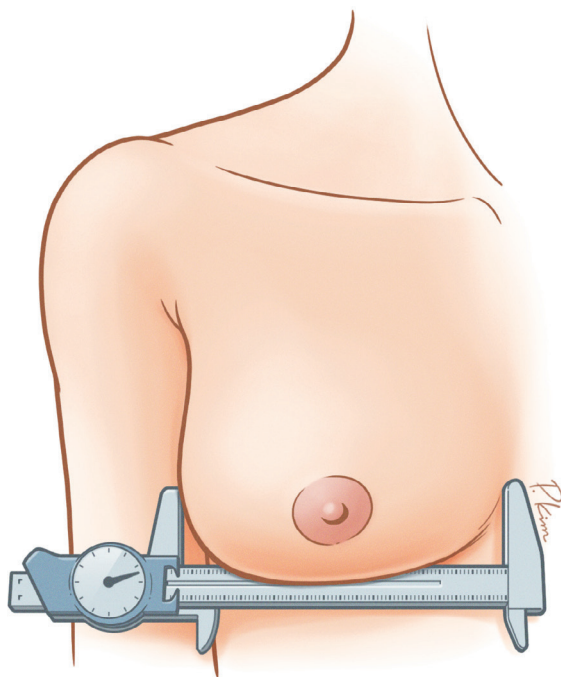
During a patient's initial preoperative evaluation, the surgeon must discuss patient-specific reconstructive options, while also addressing patient goals and expectations for both breasts. At this visit, a complete breast and oncologic history should be obtained, with particular emphasis on need for adjuvant treatment therapies including chemotherapy and radiation. While the ultimate goal of complete oncologic resolution should take precedence, the timing and coordination of reconstructive procedures can often impact reconstruction success and final cosmesis.

A careful examination and measurement of key landmarks on both breasts is critical, particularly breast base width, distance from nipple to inframammary fold, and distance from sternal notch to nipple (Figs. 18.2–18.4). Any asymmetries must be noted, in both position and size of the NAC on both breasts. Furthermore, these measurements must be repeated on the reconstructed breast through the treatment, as the NAC position can change through mastectomy and reconstruction, and this must be accounted for when planning contralateral symmetry procedures.

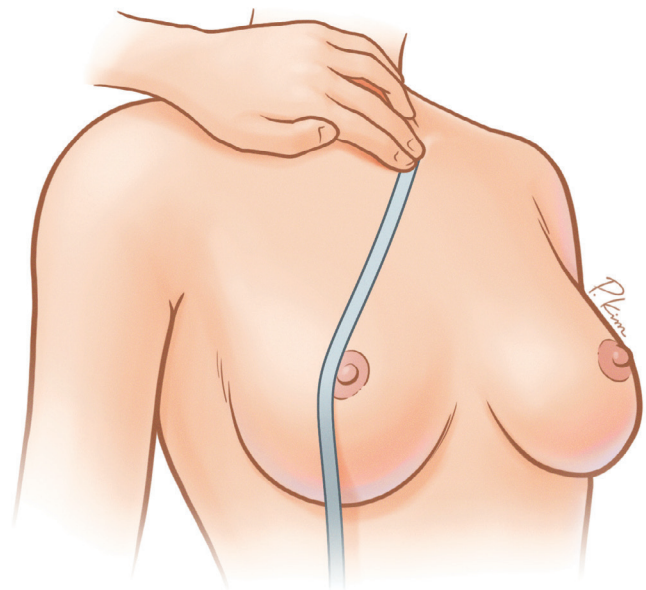
Finally, the projection of both breasts must be assessed carefully. The majority of prosthetic reconstruction is performed with high or enhanced high projection implants. This will often result in the need to either increase or decrease projection of the contralateral breast, which can be accomplished by accurately planning the augmentation mammoplasty or reduction mammoplasty, respectively.



• **Fig. 18.3** Measuring nipple to inframammary fold distance, with the breast at rest.



• **Fig. 18.2** Measuring base width of the breast mound.



• **Fig. 18.4** Measuring sternal notch to nipple distance.

Surgical Techniques

Augmentation Mammoplasty

Preoperative Markings

Key preoperative markings for landmarks in augmentation mammoplasty include the inframammary fold (IMF), the suprasternal notch to nipple distance, and nipple to IMF distance. If this is performed in conjunction with an expander–implant exchange, then markings for pocket dissection on the augmentation mammoplasty should mirror markings on the reconstructed breast for capsulotomy and pocket reshaping. The authors' preferred incisional approach for augmentation mammoplasty is the lateral IMF incision. In most cases, this incision can be kept to 4 cm for the entire procedure. Other incisional approaches include the periareolar and the transaxillary approaches.

Details of Procedure

Based on upper pole parenchyma thickness, and type of contralateral reconstruction performed, the surgeon must first select the anatomic plane of implant placement for the augmentation mammoplasty. The authors' preference is to perform subfascial augmentation, given the increased prevalence of prepectoral breast reconstruction procedures on the contralateral reconstructive breast.⁷ Subfascial augmentation offers advantages of less pain, lower risk of animation deformity, and low reported rates of capsular contracture.⁸ An upper pole pinch thickness of greater than 2 cm will allow for placement of a subfascial or subglandular breast implant for augmentation, without risk for visible implant edges in the upper pole.

When performing the augmentation at the time of expander-to-implant exchange on the contralateral breast, the reconstructed breast should be addressed first. Once this breast has been sized with the desired implant, and fat grafted, then the augmentation can be performed, and optimal aesthetic match can be attained.

When the IMF incision is chosen, this incision is marked 1 cm below the inframammary crease of the patient. Assuming the patient has a normal crease position preoperatively, this will result in the ability of the scar to lie behind the lower pole breast parenchyma, after the patient heals. When the incision is placed directly at the IMF or above, it will rise on the augmented breast, and will eventually sit on the visible portion of the patient's lower breast.

Following incision through the IMF approach, careful dissection must proceed in a superior direction, such as not to lower or displace the IMF. Once the pectoralis fascia is reached, then the implant pocket can be elevated just below this layer. Dissection should always proceed approximately 1 cm above the IMF position. From this approach, once the correct anatomic plane is identified, the majority of the dissection can be performed bluntly. Once the pocket is elevated, and the eventual implant is placed, this will result in an implant sitting posterior to both the breast

parenchyma and the pectoralis major fascia, but anterior to the pectoralis major muscle.

For those patients undergoing a submuscular implant placement, which is recommended in cases of breast deflation and reduced upper pole soft tissue coverage, the dual-plane approach is recommended. Following elevation of the pectoralis major muscle, the inferior insertion of the muscle is incised along its entire length, leaving a 1-cm cuff of muscle along the IMF. This will allow for NAC elevation and a more natural appearance of the augmentation mammoplasty. When the lower border of the pectoralis muscle is not released in this fashion, and the implant is placed in a complete submuscular pocket, the implant cannot descend to the native IMF, and this will likely result in implant malposition superiorly.

Following complete pocket elevation, the author promotes placement of all implants using a no-touch technique. Prior to implant placement, pockets are thoroughly irrigated with betadine and antibiotic-impregnated saline. Then the implant is placed in such a way that it does not contact the patient's external skin.

When the periareolar approach to implant placement is selected, the previous steps for submuscular or subfascial implant placement remain the same. The primary difference is access to the pocket, from the anterior breast incision. While the dissection can be made in a transparenchymal manner, directly through the breast to the chest wall, this will expose the implant to bacteria present within the breast ducts. Thus, it is preferable for dissection to proceed along the lower pole breast fascia, inferiorly towards the IMF. Once the fold is reached, the dissection can then proceed superiorly in the desired plane to create the implant pocket.

Following completion of the augmentation, the patient must be placed in the sitting position in the operating room, to ensure symmetry between the breasts. Specifically, the surgeon must separately assess the following aspects on both the augmented and reconstructive breast: size, shape, base width, projection, NAC position. For the patient to be satisfied with the reconstructive outcome, all these factors must align.

Reduction Mammoplasty

Preoperative Markings

When marking a reduction mammoplasty, the first landmark to place is the postoperative NAC position. This is marked by transposing the IMF anteriorly onto the breast mound (Pitanguy's point). This is then confirmed by matching sternal notch to nipple distance with the contralateral reconstructed breast NAC position, if matching a NSM.

Choosing technique for breast reduction often depends on the preoperative breast size and ptosis. When the breast has grade 2 ptosis, and a 150–800-g reduction is anticipated, a vertical breast reduction pattern is generally selected, with a superior or superior-medial pedicle. When the preoperative breast mound has grade 3 ptosis, and greater than an 800-g reduction is anticipated, an inverted-T "Wise

pattern” technique is selected. This can be performed with an inferior pedicle, or a superior/superior-medial pedicle.

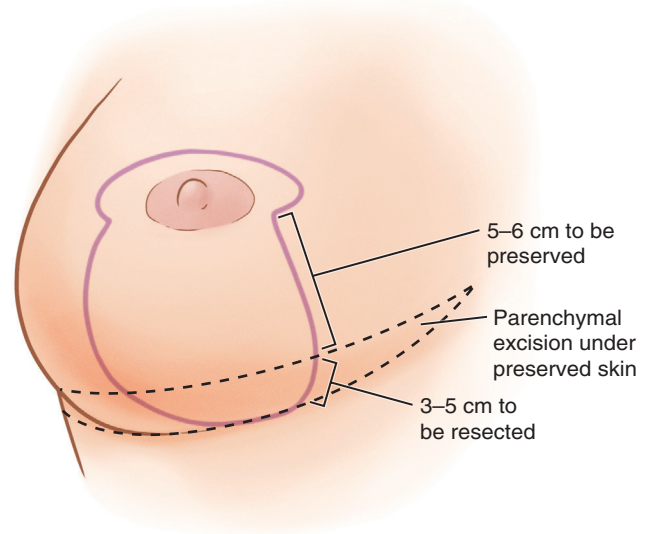
For vertical reduction patterns, the nipple position is marked at Pitanguy’s point, and is then placed 1 cm below this mark, to prevent a high-riding NAC. This is typically at a sternal notch to nipple distance of 22–23 cm. The remainder of the vertical reduction areola pattern is marked by planning the areolar circle with a 40–42-mm circumference. This is marked as a C-shaped incision, with the open area inferior. When this C-shaped dome is brought together at the two inferior edges, it creates a circle, with the stated circumference. Next, the vertical limbs are marked by displacing the breast medially and laterally, and with each, marking the vertical line from the upper point at the base of the new areola, to the inferior point just above the IMF (Fig. 18.5). The amount of force used to displace the breast during these markings will determine the tightness of the inferior vertical closure, as more force results in a wider skin resection inferiorly.

Next, the vertical extent of breast parenchyma to be preserved is determined. This is usually marked at 5–6 cm below the inferior border of the new areola (Fig. 18.6). Everything below this line represents parenchyma that will be excised, underneath preserved lower pole breast skin. Thus, this line will represent the new IMF postoperatively of the reduced breast. This accounts for the elevation of the IMF seen with this technique.

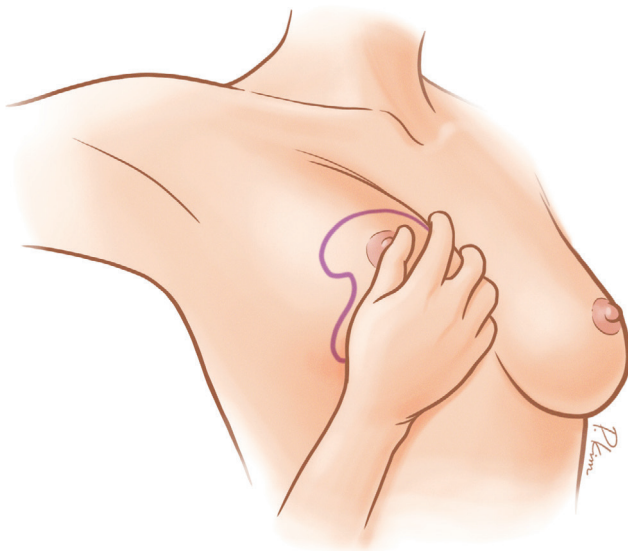
With this pattern, the authors’ preference is a 6–8-cm superior pedicle around the NAC. This results in breast parenchyma resection in the inferior vertical limb (with skin), and the lower pole areas medially and laterally (without skin). Once this is completed, the breast is closed in the vertical manner, by suturing the medial and lateral resection pillars to each other in the midline, starting at the

area of the new IMF, and moving upwards to the base of the areola. This results in the final vertical scar pattern.

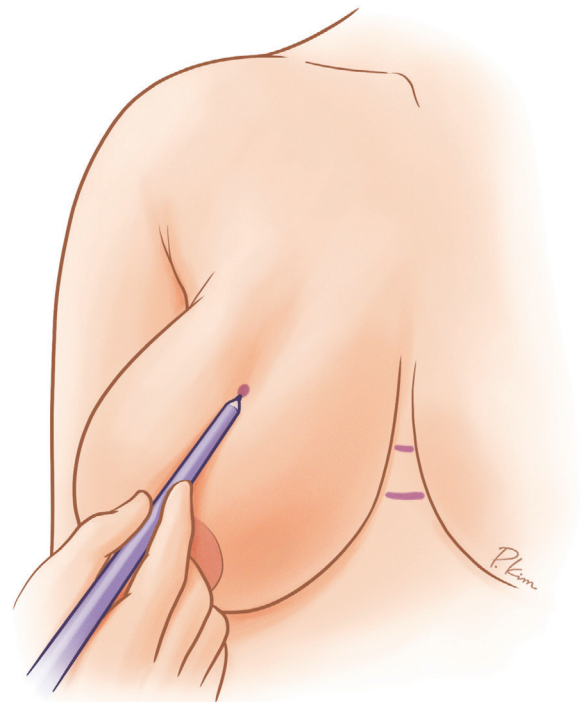
For the Wise pattern reduction, the NAC is marked at the level of the IMF (Fig. 18.7). Next, the vertical limbs of the breast marking are drawn at 7–8 cm each, and the



• **Fig. 18.6** Following the markings for vertical breast reduction, the new areola to IMF distance is marked at 5–6 cm; this line marks the location of the new IMF, and all parenchyma below this area will be excised with the reduction.



• **Fig. 18.5** Marking the inferior limbs for a vertical breast reduction, with the breast placed on gentle medial traction, and the line marked corresponding to the breast meridian.



• **Fig. 18.7** Marking the new nipple location for a Wise pattern breast reduction by transposing the IMF location anteriorly onto the breast skin, thus locating Pitanguy’s point.

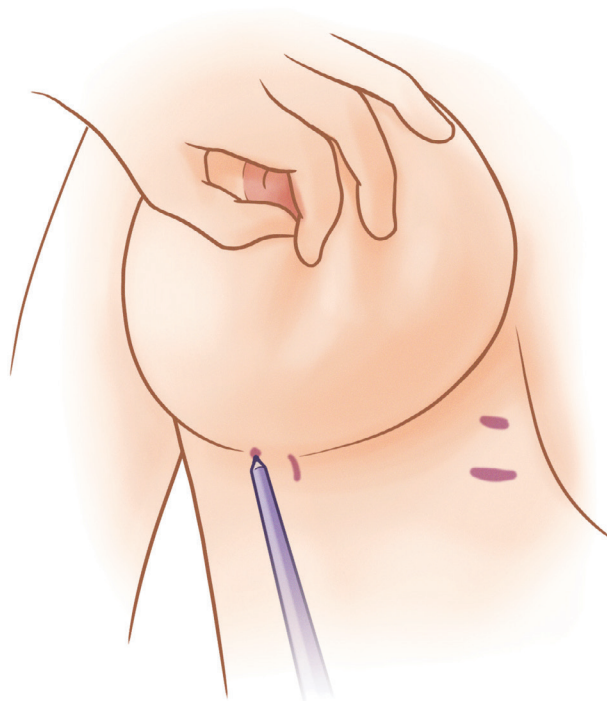
distance between the bottom of each limb is left at 5–6 cm, to avoid excessive tension on closure (Fig. 18.8). Following this, the IMF is marked along its entire extent (Fig. 18.9). Finally, the medial and lateral lines are marked from the base of each vertical limb, in a medial and lateral direction, respectively, to meet the IMF markings (Figs. 18.10 & 18.11). This results in the classic skin resection area of the Wise pattern breast reduction.

The authors' preference is to match this technique with an 8–9-cm based superior-medial pedicle for NAC perfusion. However, this Wise pattern can be performed with inferior or medially based pedicles as well.

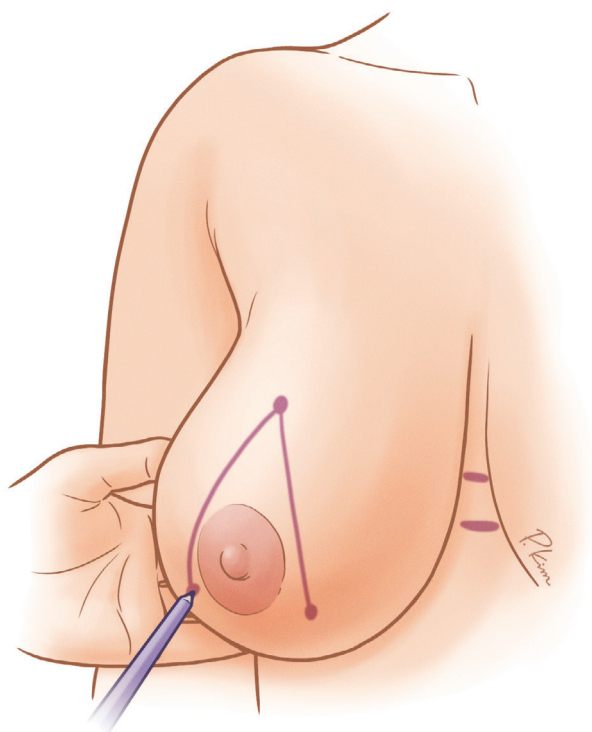
Details of Procedure

For both types of reduction mammoplasty, the pedicle is de-epithelialized, to maintain the subdermal plexus. Following this, the pedicles are developed down to the level of the chest wall, in the necessary dimensions. Great care is always taken not to undercut the pedicle from its connection to the underlying chest wall. This will ensure likely preservation of both blood supply and sensory nerves. Following this, parenchymal resection can then proceed based on the pattern.

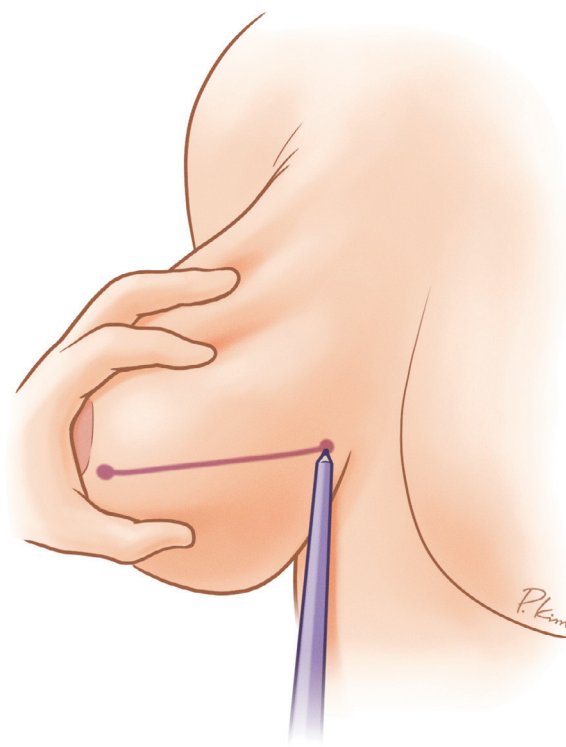
For the vertical technique, the majority of parenchyma is excised from the lower pole. Great care is taken not to over-resect medially, for maintenance of aesthetic cleavage



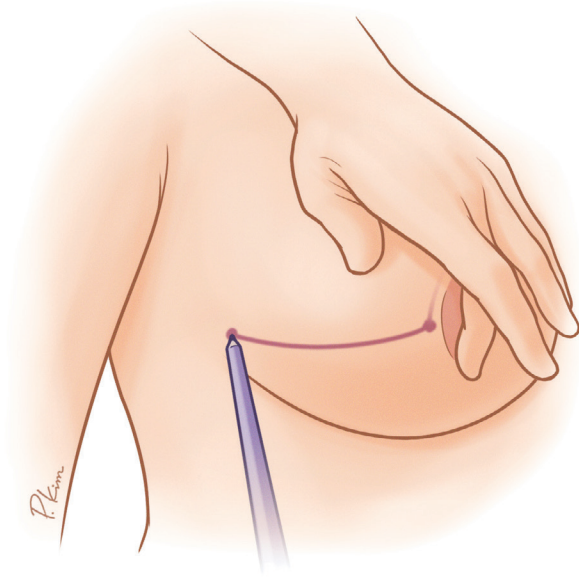
• **Fig. 18.9** Marking the IMF location for a Wise pattern breast reduction, which will represent the inferior incision location.



• **Fig. 18.8** Marking the two vertical limbs of the Wise pattern at a distance of 7–8 cm each, with a distance between the bottom of each line being 5–6 cm.



• **Fig. 18.10** Marking the medial limb of the Wise pattern breast reduction, from the bottom of the medial vertical limb, to a point at the medial edge of the breast.



• **Fig. 18.11** Marking the lateral limb of the Wise pattern breast reduction, from the bottom of the lateral vertical limb, to a point at the lateral edge of the breast margin.

line with fullness. Upon completion, the result is maintained by suturing the medial and lateral pillars of breast parenchyma to each other in the midline, and this results in long-term projection and maintenance of shape.

For the Wise pattern, the pedicle is first de-epithelialized, after all incisions are made. The pedicle is then dissected down to the chest wall. Next, tissue resection proceeds with the lower pole parenchyma and skin that hangs below the IMF. Following this, the lateral parenchyma is resected underneath the skin, to prevent superior lateral fullness upon final closure. Following complete resection of parenchyma, the patient must be placed in the sitting position when the NAC location is marked on the superior skin flaps. It is critical at this time to match it precisely with the position of the contralateral breast reconstruction, in cases of NSM. Once the nipple position is marked on the superior skin flaps, the pedicle is rotated into place to allow for appropriate positioning. Additional skin resection can then occur with the patient sitting, and the breast can be closed in the inverted-T fashion.

Symmetry of nipple position is one of the first attributes patients notice when assessing their reconstructive breasts, and thus is critically important to match on both sides.

Following completion of the reduction, the patient must be placed in the sitting position in the operating room, to ensure symmetry between the breasts. Careful attention must be paid to nipple position and breast size. Any modifications can be made at this point, prior to waking the patient. If nipple position needs to be adjusted, the breast skin envelope and breast parenchyma can be repositioned or re-excised further, to change the position of the breast around the NAC.

Mastopexy

Preoperative Markings

The markings for mastopexy largely follow those of the reduction mammoplasty, and the technique can be combined with either a parenchymal resection for simultaneous reduction in size, or only skin resection, for mastopexy alone.

For small amounts of ptosis correction, moving the NAC position by 1–2 cm for correction of grade 1 ptosis, the crescent or circumareolar mastopexy technique can be used.⁹ The crescent technique marks a direct superior lift of the NAC by excising superior periareolar skin. While this technique is beneficial in symmetry procedures for correcting small differences in NAC position, care must be taken not to use it for larger lifts, as it will result in vertical elongation of the areolar shape.

For those cases of grade 2 ptosis correction, vertical technique is employed for mastopexy. Finally, when correcting grade 3 ptosis, a Wise pattern skin resection is used.

Details of Procedure

Similar to reduction mammoplasty, the vertical and Wise pattern mastopexy proceeds with similar technique, but a focus on skin excision and tightening, with nipple transposition on the previously described pedicles. For straight mastopexy, minimal to no parenchymal resection is performed. The skin resection should proceed as marked, and upon completion, temporarily closed through tailor-tacking, and the patient sat up to assess symmetry. This can be repeated multiple times, with the breast being checked each time for position and shape, and the ability to safely excise more skin around the chosen pattern, as needed for symmetry.

Autologous Fat Grafting

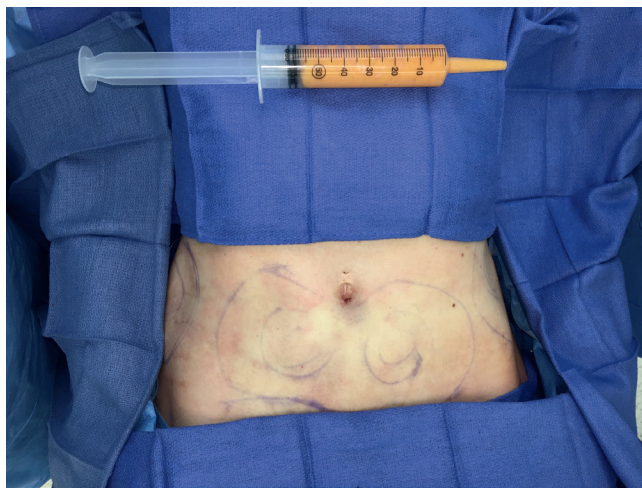
Preoperative Markings

In assessing a patient for autologous fat grafting, the surgeon must first select the correct donor sites for fat harvest. The infraumbilical abdomen and thighs are the most commonly chosen donor sites, due to both their accessibility with a patient in the supine position, as well as the high concentration of viable adipocytes in these areas.¹⁰ Thus, it is advisable that these areas be used as the primary option for fat harvest when available.

Preoperatively, the surgeon must carefully mark the zones of planned liposuction, with the patient standing, such that all donor-site areas are used equally and symmetrically, to avoid a donor-site defect. Additionally, the surgeon must precisely identify the areas of planned fat injection preoperatively, again with the patient standing (Fig. 18.12). They also must plan the proper cannula entry points and direction of fat injection. The planned skin injection sites must allow access to the entire breast mound, and also allow for concealed scars.



• **Fig. 18.12** Preoperative photograph of a patient marked for autologous fat grafting to the left breast, from an anterior abdominal donor site.



• **Fig. 18.13** Intraoperative view of fat ready for injection, following harvest and processing from the superficial abdomen of the patient in Fig. 18.1, showing minimal oil or blood content.

Details of Procedure

Intraoperatively, the donor sites must first be prepared for fat harvest. The targeted areas should be infused with standard tumescent solution, consisting of an isotonic fluid mixed with epinephrine and lidocaine at safe concentrations (Fig. 18.13). Once the hemostatic effect of this has taken place, fat can then be harvested. The authors' preference is to use standard suction-assisted liposuction (SAL) techniques, with a blunt tip cannula, into a filtration device for



• **Fig. 18.14** A fat injection cannula being passed into the mastectomy skin flap, for fat grafting prior to permanent implant placement. As the cannula is withdrawn from this pass, 1 cc of fat will be injected into the subdermal tract.

fat collection and washing. This is done at 250-mmHg negative pressure for harvest. Following this, fat is minimally processed through a light wash in the filtration device, to remove oil and blood, and then reloaded into an injection syringe. This minimal processing results in more viable fat graft than more aggressive processing techniques such as centrifugation.¹¹

Following this, fat can then be injected into the necessary breast for enhancement of aesthetic outcomes, correction of contour deformities and areas of hollowing, and improvement of symmetry. As previously stated, the author uses fat grafting more commonly on the reconstructed breast for upper pole volume restoration and symmetry improvement, but also in some cases on the contralateral native breast. In this way, injection into the reconstructed breast enhances symmetry, as it allows this breast to better match the maintained upper pole volume and slope of the native breast.

The key to increasing fat survival is to maximize contact of each injected string of adipocytes with the surrounding host vascularized tissue. To achieve this, the approach during injection is to infiltrate many thin strands of fat, dispersed equally throughout the soft tissue envelope. Furthermore, they should be injected in opposing directions to each other, through different access sites; this criss-cross pattern of injection allows for fat to be uniformly and smoothly injected to fill the area, with good contact of all fat to surrounding vascularized tissue. Each pass of the syringe with these cannulas should infiltrate 0.5 cc to 1 cc of fat, in an attempt to avoid fat necrosis (Fig. 18.14). Injection of large boluses or clumps of fat will result in central fat necrosis, oil cysts, or microcalcifications within these injection areas.

Case Examples

CASE 18.1

A 40-year-old female with left breast cancer ([Case 18.1.1](#)), prior to surgical treatment. She elected to undergo left breast nipple-sparing mastectomy and left breast two-stage prepectoral breast reconstruction, along with right breast augmentation at second stage for symmetry. The patient declined autologous fat grafting at the time of the second-stage operation, expander-to-implant exchange, and returned 9 months postoperatively with left breast upper pole rippling

and hollowing ([Case 18.1.2](#)). She then underwent a revisionary procedure for symmetry, with planned left reconstructed breast autologous fat grafting, and right native breast crescent mastopexy, for improved symmetry ([Case 18.1.3](#)). At this operation, she underwent 100 cc of autologous fat grafting to the left breast. Postoperative view at 6 months following revision, shows improved aesthetic symmetry between the bilateral breast upper poles and nipple position ([Case 18.1.4](#)).



• Case 18.1.1



• Case 18.1.3



• Case 18.1.2



• Case 18.1.4

CASE 18.2

A 48-year-old female with a history of prior right breast nipple-sparing mastectomy, and no reconstruction at that time (Case 18.2.1). She then elected to undergo right breast delayed reconstruction with two-stage expander/implant

approach. At the second stage operation, she underwent a left breast augmentation in the subfascial plane, for size and shape symmetry. Patient is shown 12 months following this operation (Case 18.2.2).



• Case 18.2.1



• Case 18.2.2

CASE 18.3

A 41-year-old female with a history of left breast cancer, who elected to undergo left breast nipple-sparing mastectomy, and immediate left breast two-stage expander/implant reconstruction with a prepectoral reconstruction approach. The patient also underwent left post-mastectomy radiation between the two operations. At the second stage operation, she underwent a right breast augmentation in the subfascial plane, for size and shape symmetry. Patient is shown 12 months following this operation (Cases 18.3.1–18.3.3). The right breast augmentation allowed for shape, size, and projection symmetry with the reconstructed breast. Furthermore, the reconstructed left breast underwent autologous fat grafting at time of implant exchange, offering appropriate left breast upper pole volume and contour, despite mastectomy, to match the native breast.



• Case 18.3.1



• Case 18.3.2



• Case 18.3.3

Management of Complications

In general, complications following symmetry procedures such as reduction mammoplasty, augmentation mammoplasty, mastopexy, and autologous fat grafting are uncommon. The most common complications are infection and hematoma. These are treated with antibiotics (oral or intravenous) or surgical washout in the case of infection, and with surgical evacuation for hematoma. In cases of augmentation and infection, it may be necessary to leave the implant out for some time prior to replacement, allowing infection to subside in the interim. With mastopexy and reduction mammoplasty, delayed wound healing can occur in some cases, along the incision lines. This is treated with prolonged wound care until secondary healing occurs.

In cases of autologous fat grafting, complications usually relate to over-injection of fat, and resulting fat necrosis or oil cysts. These present as palpable masses in the breast and, if on the side of previous cancer, necessitate a biopsy. They can then be removed percutaneously once confirmed benign.

Conclusions

Unilateral breast reconstruction remains one of the most challenging procedures in breast reconstruction, given the need to ultimately match this reconstructed breast to a native breast. This is especially challenging in the setting of adjuvant treatments to the reconstructed breast, such as radiation, given the alterations this can produce in aesthetic breast appearance. To produce symmetry, the techniques discussed in this chapter offer the best approach, as they allow for alteration of size, shape, position, and projection of either breast, and most commonly the native breast, for symmetry improvement. Ultimately, these procedures are equally important to the reconstruction, as reconstructive success is judged heavily on attaining bilateral symmetry.

PEARLS FOR SUCCESS

- Selecting the proper procedure for symmetry is the key to a successful outcome.
- These procedures allow for matching of shape, size, projection, and position of the breasts.
- When the native breast requires size increase alone, with increased projection, augmentation will offer the best option for symmetry.
- When planning augmentation, patients with adequate upper pole soft tissue coverage and pinch test are excellent candidates for subfascial augmentation.

- When both a significant size reduction and correction of ptosis are required, either a vertical or Wise pattern reduction mammoplasty can be utilized.
- Vertical reduction mammoplasty with superior-medial pedicle offers the longest lasting ptosis correction, due to parenchymal reshaping, with the most youthful-appearing breast, to best match the reconstructive side.
- For small nipple transpositions (1–2 cm) to correct ptosis, the crescent mastopexy is a powerful and efficient technique, given the small skin resection; this technique should be reserved for patients with an ideal NAC to IMF distance of 5–7 cm.
- Autologous fat grafting is more commonly performed on the reconstructive breast, for restoration of missing upper pole soft tissue volume, and in this way enhances symmetry of this area with the native breast.
- Autologous fat grafting is highly technique dependent, and use of less aggressive fat processing techniques, such as filtration, offers more viable fat and higher fat survival rates.

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19

Fat Grafting for Total Breast Reconstruction

ROGER KHALIL KHOURI AND KIMBERLY SOPHIA KHOURI

Introduction

To reconstruct total mastectomy defects, implants and flaps were traditionally the only available options. Fat grafting, for total breast reconstruction, is now an evolving third alternative. Over the past 15 years we have refined this procedure and we are now able to, in most cases, restore aesthetically pleasing breasts that feel and look like the original, with the added benefit of normal sensation.¹ Total breast reconstruction with external vacuum expansion (EVE) and autologous fat transfer (AFT) is minimally invasive, and can over multiple stages recreate an autologous breast mound.

Total breast reconstruction with EVE + AFT generates a three-dimensional vascularized and innervated graft recipient scaffold where large amounts of carefully seeded lipoaspirate can survive to regenerate the breast mound.

Recreating a breast mound takes time; although minimally invasive, fat grafting for breast reconstruction is still plastic surgery. We build the mound in a stepwise fashion with 3–6 procedures performed in succession over the course of 9–18 months. Interestingly, many cases of implant and flap breast reconstruction include some fat grafting as an adjunct. There is even a trend towards smaller flaps to enlarge the recipient site along with more fat grafting sessions. The fat grafting procedures are outpatient, and therefore the number of procedures is less of an issue. It is the cost:benefit ratio and the quality of the final result that ultimately matter.

In this chapter we will elaborate on the principles behind large volume AFT and describe our technique that adheres to these principles.

Indications and Contraindications

The technique of total breast reconstruction with fat grafting is indicated for women who wish to avoid invasive procedures and alloplastic implants. The goal is similar to any breast reconstruction: restore her body with natural-looking

and sensate breasts. After mastectomy surgery, flap transfer surgery has been the best autologous tissue option. However, the recovery is long and there are donor-site scars distant to the breast. Implant-based reconstruction is considered less surgery, but many women are reluctant to use foreign materials and are not fully satisfied with the results.²

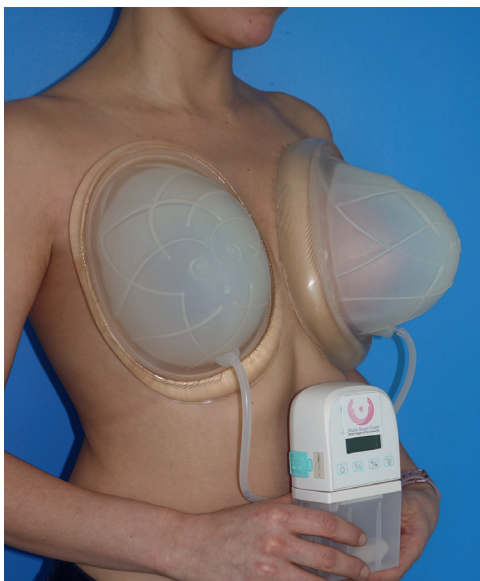
The only absolute contraindication to total breast reconstruction with fat grafts is active smoking. Fat grafting has very poor outcomes in smokers. Additionally, blood thinners, anticoagulants, or any vitamins/herbs that may prolong bleeding time must be discontinued well before the surgery. This is primarily due to the fact that extravascular blood from excess bleeding during cannula excursion will compete with the fat for graft-recipient interstitial space. When tissues become taut with extravasated blood, there is less room for the fat grafts.

If a patient has a mastectomy that is irradiated and/or has suffered scarring from prior reconstruction failures, then the patient has to understand that total breast reconstruction with fat graft will involve a minimum of five procedures over 12–24 months.

Since EVE is crucial to the success of this technique, inability or unwillingness to comply with the EVE preparation protocol is a major drawback. In order to eliminate non-compliance, patients test-wear EVE in the office for 20–30 minutes. When they become comfortable with wearing the device, we educate them on proper use and consistency with its wear. From our clinical experience, we have found that most intelligent educated women can bear the inconvenience of EVE for a few hours a day over a few weeks. Therefore, EVE is more ideal for educated women who are willing to work with the surgeon and personally contribute to the goal of achieving a breast reconstruction through a sequence of less invasive procedures.

Preoperative Evaluation

Preoperatively, patient selection and education are paramount and cannot be understated. The patient must



• **Fig. 19.1** The EVE external vacuum expansion device consists of two polyurethane domes with silicone gel donut rims that maintain a vacuum seal against the skin and serve to dissipate shear and counterforces. A microprocessor regulates the vacuum pressure and records patient compliance.

understand that successful results depend upon her active contribution, and that reconstruction does not occur overnight. Additionally, unless they have had a total mastectomy, all patients are required to have preoperative MRI in order to exclude occult pathology and obtain a baseline of residual breast tissue quality and volume (Fig. 19.1).

Surgical Techniques

Breast mound reconstruction with EVE + AFT involves minimal incisions; therefore, there is no conventional exposure and no tissue dissection. However, there is much more to successful AFT than syringes, cannulas, and strong arms. The final outcome depends upon a series of steps that need to be individually optimized. The result is the product of the weakest link among these individual steps. Each step in this reconstructive process has the potential for failure and can doom the reconstruction.

The outcome is limited by the rate-limiting step and investing in non-rate-limiting steps is futile. It is important to consider the process in its entirety and to avoid focusing on only one factor while disregarding the others.

Fundamental Concepts of Fat Graft Survival

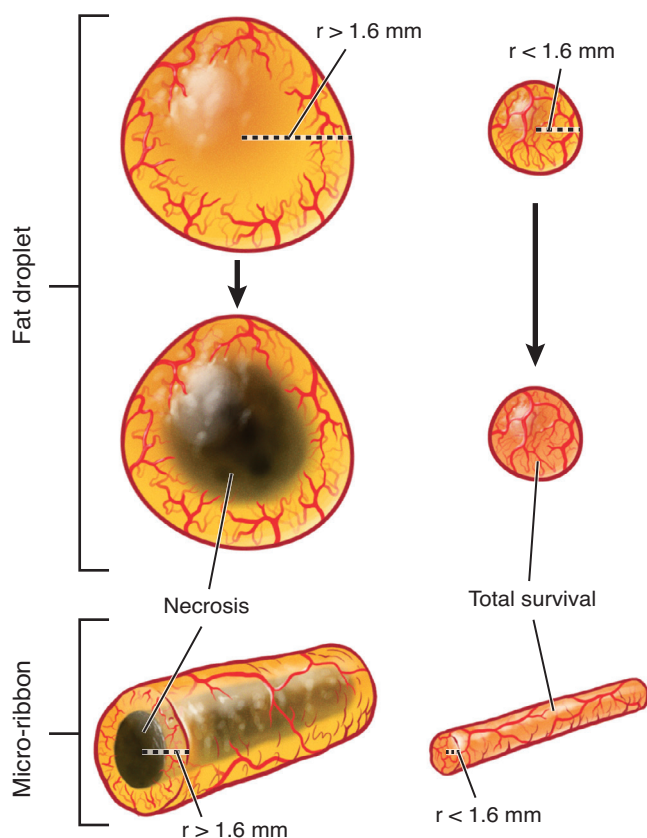
Avascular free fat grafts cannot survive without revascularization. To ensure that avascular grafts re-vascularize, it is important to understand the fundamentals of 3-D revascularization. Just like the familiar 2-D skin grafts, close graft-to-recipient contact is essential for revascularization. Arbitrary bolus fat injections to plump up a breast mound are doomed for failure, because without restoration of blood supply the result is widespread necrosis.³

It has been well established that an inserted fat graft droplet has three layers or zones.⁴ The most peripheral zone is in direct contact with the recipient bed and will readily re-vascularize through neo-angiogenesis. Unfortunately, neo-angiogenesis is a slow process, and less than 1 mm of the outermost shell can re-establish blood supply before the deeper adipocytes succumb to hypoxia. Just below this layer lies the regenerative zone, where only the more hypoxia-resistant adipose-derived stem cells (ASC) or stromal vascular fraction can re-vascularize, survive, and regenerate a new adipocyte population. Deep to this regenerative zone lies the necrotic zone, where no cells can survive.^{5,6} Studies have demonstrated that even under ideal circumstances, the maximum depth of the graft survival zones is 1.6 mm, and that the rate-limiting step in this process is oxygen diffusion.⁷ Revascularization depends upon this critical graft-to-recipient interface, and in large volume fat grafting, only “micro-droplets” or “micro-ribbons” in the 3-mm (1.6 mm × 2) range re-vascularize and survive. In order to optimize this graft-to-recipient interface, large graft volumes must be skillfully and precisely delivered in a 3-D distribution as a fine mist of 17- μL ($4/3\pi r^3$) micro-droplets, or since we deliver through cannula passes, 3-mm wide micro-ribbons that do not coalesce. Droplets larger than 17 mL or ribbons wider than 3.2 mm will invariably suffer central necrosis (Fig. 19.2).

Principles of Fat Graft Harvesting and Preparation

We obtain the fat cells by simple liposuction. In addition to fat cells, the lipoaspirate contains fibroblasts, endothelial cells, pericytes, white blood cells, platelets, and adipose-derived stem cells.⁸ In our experience we find it important to graft back the entire group of cells not just the pure adipocytes. In order to get the best graft, we favor extensive tumescence of the donor sites (more than 1 L per donor area) to obtain non-bloody aspirates that can rapidly sediment. We prefer harvesting in a closed system with a constant low-pressure (300-mmHg) spring-activated syringe suction to minimize trauma to the adipocytes. While vacuum pumps can also deliver controlled low pressures they often expose the fat to high airflow in the necessary long tubing before they reach the rigid collection containers. We harvest with a thin, 2.7-mm cannula with 12 holes 1 × 2 mm each. This allows us to harvest smaller fat droplets through tiny puncture wounds that leave minimal scars. Our preferred cannula also has winglets at the opening that invite more fat, while the rough barbs help harvest more stromal vascular tissue.⁹ Instead of a scalpel we insert the cannula through 14G needle punctures all around the donor site and we liposuction with criss-crossing passes through these multiple entry sites. This technique provides for the most even harvest with minimal scarring (Fig. 19.3).

While some advocate removing inflammatory cells and debris through filtration or washing, others champion the opposite and add platelets that are rich in inflammatory



• **Fig. 19.2** Free grafts will not survive without revascularization. Angiogenesis can only revascularize the outermost 1.6-mm shell of a fat graft droplet while the inner, deeper core dies from lack of perfusion. Therefore, only the tiniest droplets with radii less than 1.6 mm = 17 μL ($V = 4/3\pi r^3$) can totally survive. A 1-mL droplet ($r = 6.2$ mm) might only have its outermost 1.6-mm shell survive while its 4.6-mm (volume = 0.41 mL) central core succumbs to ischemia. Therefore, even a small 1-mL droplet will have at least 41% necrosis. When injected continuously through a cannula, micro-droplets become cylindrical micro-ribbons. Ribbons with radii wider than 1.6 mm will inevitably suffer central necrosis. For revascularization to occur, it is therefore crucial to deliver micro-ribbons not wider than 3 mm. (Modified from Eto H, Suga H, Aoi N, et al. The fate of adipocytes after nonvascularized fat grafting: Evidence of early death and replacement of adipocytes. *Plast Reconstr Surg.* 2012;129:1081–1092. Reprinted with permission.)

agents. Efforts to remove from the graft the very same tissue components present at the recipient site are futile. Based upon theoretical and laboratory advantage, some advocate adding stem cells. However, the few controlled clinical studies showed no benefit for this cumbersome and regulatory obstacle-ridden technique. Therefore, since there is no conclusive evidence for the clinical advantage of adding to or removing substances from the harvested adipose tissue, we prefer to take a purist approach, and leave the graft with its surrounding microenvironment as minimally manipulated as possible. As a matter of fact, there is mounting evidence that the entire harvested liposuction matrix is required for optimal clinical result.

We allow the lipoaspirate to gravity sediment in the collection bag for a few minutes and simply drain the infranatant fluid and collect the supernatant fat into a lipografting



• **Fig. 19.3** Barbed 12-hole, 12G harvesting cannula: a thin, 2.7-mm (12G) cannula can be inserted through needle punctures that leave minimal scars while its 12 holes (1 $\times$ 2 mm each) can efficiently harvest smaller fat droplets. Our preferred cannula also has winglets that invite more fat and rough barbs that help harvest a greater stromal vascular fraction. Because needle punctures leave minimal scars, we can afford to insert the cannula through multiple entry sites all around the donor site and liposuction in a criss-crossing pattern for a more even harvest out of a wider surface.

bag. Along with most surgeons with extensive experience with large volume fat transfer, we moved away from centrifugation. This is supported by a recent prospective controlled randomized study.¹⁰ We use the Lipografter (MTF, Edison, NJ) to perform the graft harvesting, preparation, and reinjection in a closed system (Fig. 19.4).

Principles of Recipient Site Preparation

Just as in 2-D grafting where the size of the graft must match the surface of the wound, in 3-D grafting, we cannot graft more than what the recipient can expand to accommodate. In post-mastectomy breast reconstruction, the recipient site capacity is quite limited. We use EVE to prepare the recipient bed by increasing its compliance. This increases the amount of graft the mastectomy defect can accept without crowding and without increasing the interstitial pressure to levels that jeopardize perfusion.^{5,8} EVE stretches blood vessels and creates new ones, and this angiogenesis primes the tissues for better revascularization.^{11,12} Along with the blood vessels, sensory nerves are also stretched and it is this neo-neurogenesis that restores sensation to the regenerated breast mound. EVE also creates the skin envelope required for forming a breast mound. There is also evidence that it primes the recipient tissue to accept more grafts by activating pathways independent from the enhanced vascularity.^{13,14}



• **Fig. 19.4** Lipografter® in harvesting mode. To minimize trauma we prefer to harvest with a low pressure, low air flow device. The K-VAC syringe has a ribbon spring that maintains an even 300-mmHg aspiration pressure along the entire excursion of the plunger. Pushing the plunger back in re-cocks the spring and the large-bore tissue valve (AT-valve) interposed between the syringe and the harvesting cannula automatically purges the aspirate to the collection bag. This closed system allows us to efficiently harvest with a controlled low-pressure syringe without losing precious time de-cannulating, cannulating and switching syringes (Lipografter, MTF, Edison, NJ). In order to loosen up the tissues for a smoother harvest and to obtain a non-bloody aspirate that will rapidly sediment, the donor site has to be extensively and tightly tumesced.

EVE is worn like a bra for a few hours a day, every day for about 2–3 weeks prior to surgery. From our extensive empiric experience, we determined that the optimal therapeutic dose that prepares the breast for autologous fat transfer is a minimum of 200 hours over the 15 days immediately preceding the grafting with a vacuum pressure that alternates 60–0–60 mmHg for 3 minutes on and one minute off.

Principles of Fat Graft Delivery

Fat grafting for breast reconstruction is a blind procedure that requires craftsmanship, artistry, and adherence to fundamental principles. Since the tip of the cannula is not exposed, the surgeon does not see the graft as it is delivered under the skin, and is therefore never certain that distribution is even or optimal. However, just like the liposuction technique, where the tip of the cannula is not visualized but even and diffuse harvesting can be achieved through multiple entry sites and criss-crossing passes; we graft the fat in a similar fashion. The goal is to deliver micro-ribbons of fat into separate planes, to avoid coalescence, and to maintain an organized pattern of grafting so that there is no under- or over-grafted site. Like a sprinkler system, the way to evenly and diffusely deliver specks over a broad expanse is to randomly spray out a fine mist through many sprinkler heads, rather than massively pouring a stream out of a few large-bore hoses. With this multiple fine sprinkler system arrangement, we achieve “evenness through randomness” (Fig. 19.5).

Graft delivery is of paramount importance and is the least studied component of AFT. If the surgeon injects the

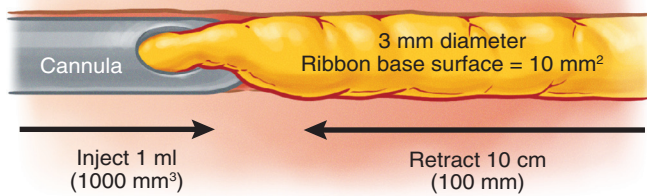


• **Fig. 19.5** Lipografter in grafting mode. To deliver fine ribbons it is important to use a small syringe. The AT-valve allows us to graft directly from the bag with a 3 mL syringe without having to switch syringes, cannulate and decannulate. We use a single hole 14G (2.4-mm) 25-cm long spatulated tip cannula and diffusely deliver specks of fat over a broad area as a fine mist. With this arrangement, we achieve “evenness through randomness.” We prefer to use a curved cannula as it is better at following the curved contour of the body and at going through different paths. Furthermore, by keeping the tip pointing up, we reduce the risk of inadvertent body cavity penetration. This closed system also leaves one hand free to control the cannula tip and the grafted tissues.

fat without moving the cannula, the result is a blob of fat. If, on the other hand the surgeon retracts the cannula over a large distance as he injects the same amount, the result is a thin ribbon. The size of the ribbon delivered is therefore a function of volume injected per distance of cannula travelled. Recognizing that 3 mm is the widest ribbon that can re-vascularize, we calculate its surface area to be approximately 10 mm². Therefore, for each 1000 mm³ (1 mL) delivered, the cannula has to retract in its channel for 100 mm or 10 cm. This is how we derive the cardinal rule of 10 cm of cannula excursion per 1 mL of fat graft delivery. Note that this rule applies regardless of the cannula diameter, the size of its hole, the pressure of injection, or the rate of injection in mL/sec (Fig. 19.6).

Since the surgeon driving the cannula cannot advance it much faster than 10 cm/sec, the pressure and shear forces at 1 mL/sec are minimal, and the graft is delivered as a fine mist in all planes and all directions with high survivability.

Over the years, we have developed several mottos of graft delivery craftsmanship: “No injection without motion,” “inject <1 mL/10 cm of cannula motion,” “sprinkle with precision,” “smaller syringe leads to greater precision,” and “no two motions in the same direction.” The subdermal and subcutaneous planes are the most preferred sites for grafting since they expand most with EVE, and augmenting these most superficial planes yields more projection than deeper planes. Grafting the pectoral muscle is ideal in immediate



• **Fig. 19.6** Fundamental principle of graft delivery. This illustration demonstrates the graft delivery limit of 0.1 mL graft injection/cm of cannula motion. Injecting without moving the cannula delivers a blob, whereas injecting that same volume while retracting a long distance in the created tunnel leaves behind a ribbon. The caliber of the delivered ribbon is a function of the injection volume delivered per centimeter of cannula retraction. The larger distance the cannula retracts, the thinner the ribbon. Therefore the size of graft ribbon delivered depends mostly on the rate of injected volume per distance of motion covered while injecting. (Adapted from Khouri RK, Khouri RK. Current clinical applications of fat grafting. *Plast Reconstr Surg.* 2017;140(3):466e–486e. Reprinted with permission of PRS.)

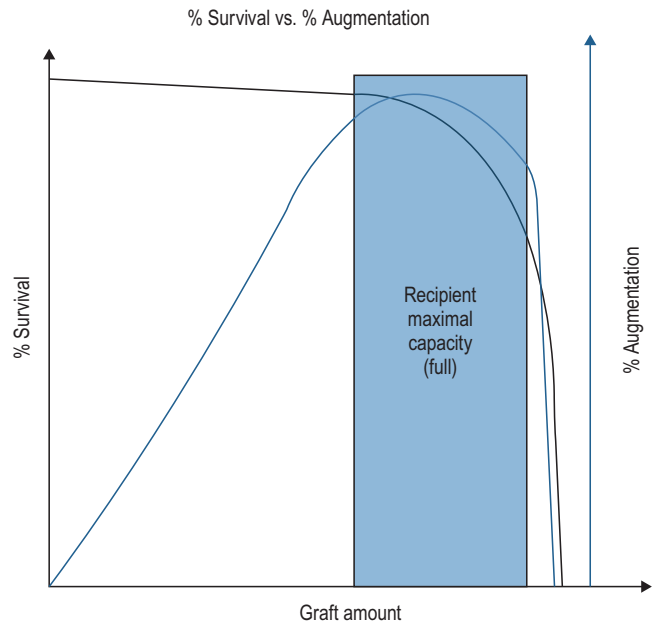
reconstruction because the restrictive fascia has been removed and inserting thin graft ribbons in between the teased muscle fibers can be performed under direct vision. Grafting the retro-pectoral space should be performed cautiously with the tip of the curved cannula pointing upwards to avoid a pneumothorax.

Principles of Post-Graft Care – the Support

Postoperatively, we immobilize the breast for 10 weeks to prevent deflation and the shrinking of natural recoil. We place an adherent conforming splint that immobilizes the graft to help angiogenesis. Furthermore, by counteracting recoil, the splint places the tissue under tension and acts as a passive external expander. Alternatively, if the patient does not tolerate the splint we resume EVE at the now constant 20 mmHg. This post-grafting care preserves the postoperative swelling and creates a chronic edema state that is apidogenic.¹⁵ Adhering to these straightforward principles allows us to maximize the likelihood of obtaining consistently favorable results.

Fundamental Concepts of Tissue Augmentation With Fat Grafting

To regenerate a breast mound out of a mastectomy defect, the goal is volume augmentation with healthy well-vascularized fat. Small amounts grafted into a large recipient might have excellent percentage survival, but will result in minimal augmentation. Percentage graft survival therefore gives little insight to what truly matters in large volume augmentation. Percentage volume augmentation, which is volume increase relative to the original recipient site volume, is therefore a much more relevant outcome measure than percentage graft survival. In contrast to most of the literature, we submit



• **Fig. 19.7** This graph reveals that at small graft amounts, the percentage survival (black curve) might be very high, while the percentage augmentation (blue curve) is still low. With increasing graft amounts, percentage survival decreases while percentage augmentation increases until maximal capacity is reached. This is the point of optimal graft to recipient match. Beyond this point, additional grafting is counterproductive. With more grafting, there is more necrosis and a worsening of the augmentation. The goal is to therefore remain as close as possible to maximal capacity without over-grafting and falling off the curve. Pre-expansion with EVE increases the maximal recipient capacity and shifts this curve to the right to increase maximum percentage augmentation. (Reproduced from Khouri RK, Khouri RK. Current clinical applications of fat grafting. *Plast Reconstr Surg.* 2017;140(3):466e–486e. Reprinted with permission of PRS.)

that the relevant measure of success should be percentage volume augmentation (Fig. 19.7).

With ideal grafting conditions, the maximum percentage augmentation of 30–50% is reached at maximum recipient capacity. Grafting beyond recipient capacity is counterproductive. Since fat is not a tissue expander, we cannot expect the injected fat to significantly stretch the tissues and at the same time survive the pressure of expansion. More grafts, however, can survive in a primed and pre-expanded recipient. Therefore, through external vacuum expansion, doubling or tripling the recipient capacity allows more of the diffusely injected graft to simply occupy the expanded scaffold. Our experience has shown that tripling of the recipient volume through external vacuum expansion prior to grafting typically results in doubling of the original breast volume.

Practical Techniques That Adhere to Above Principles

Donor-Site Marking

Our preferred harvesting site is the posterior flank and upper inner thighs. The “no harvest” zones include any natural concavity and the buttocks.

Preoperative Estimation of Graft Amount

The amount of graft harvested must match the recipient capacity. To estimate donor-site availability, we resort to the “palm and pinch” technique. This technique allows us to determine the surface, the thickness, and the compliance of the recipient site. For a rough estimate of the recipient volume, we employ the “palm measure.” Using the estimate of an average male surgeon’s hand to be 20 cm from the tips of the fingers to the wrist and 10 cm across, we use a flat palm over the recipient to measure the surface area as a fraction or a multiple of a 200-cm² palm. We employ the “pinch measure” by pinching and folding over the subcutaneous fat to give an estimate of tissue thickness and compliance. This method is applicable even for thin patients since a 0.25-cm layer of fat harvested over the surface area of a palm will yield 50 mL (200 cm² × 0.25 cm). With our thin cannula that affords multiple needle puncture wound entry sites, we can evenly harvest 250 mL solely from the anterior surface of a woman’s thigh that has five “palm measures.” Patients are rarely turned away for lack of available fat. From clinical experience, we prefer thin patients to overweight ones, because, per unit of volume, their fat has more cell than oil.

Recipient Site Marking

We mark the breast using a clock face for reference, from 12 noon and proceeding in a clockwise fashion around the breast. In the lower half, we fan out multiple radial passes a few degrees apart, placing micro-ribbons of fat in either the subdermal or deeper subcutaneous spaces. We generally alternate each plane for odd- or even-numbered clock-face hours. The upper half is reserved for the deepest muscular and submuscular planes. The 9- to 11-o’clock positions are ideal for grafting the pectoralis muscle. The entry sites are made using a 14-gauge hypodermic needle. To ensure that no fat cell is more than 1.6 mm from a recipient capillary, we use a 14G (2.4-mm) 25-cm long curved and spatulated tip single hole cannula that delivers approximately 2.5 mL, or 0.1 mL/cm at a rate of 0.1 mL/cm.

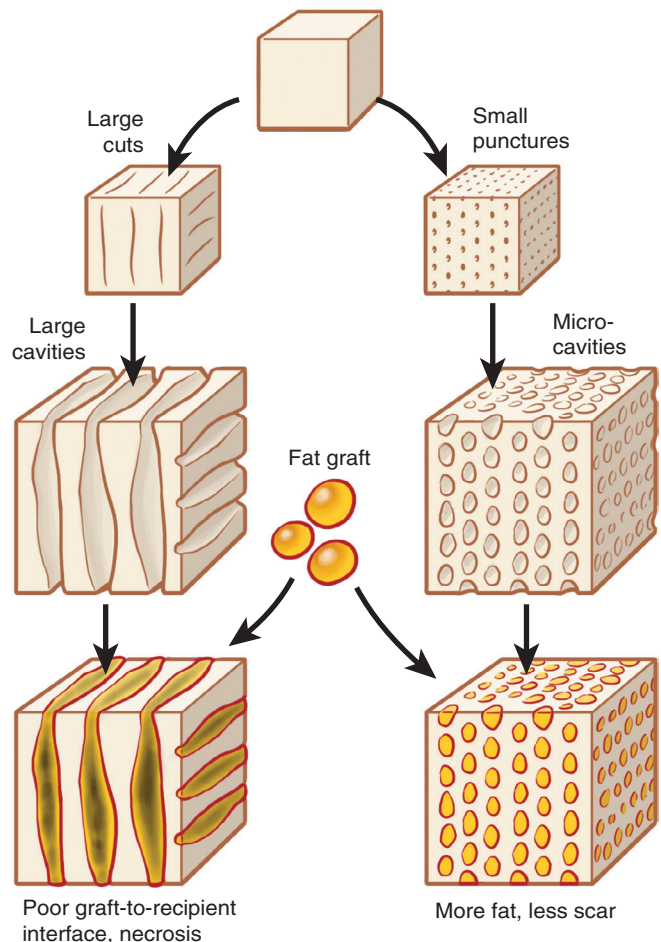
Grafting Technique

Using 3-mL syringes for large volume autologous fat transfer requires hundreds of syringe switches. In order to remain efficient and sprinkle micro-ribbons of fat, we use a two-way large-bore tissue valve (Lipografter, MTF, Edison, NJ) that transfers fat from the collection bag to the syringe and then to the patient automatically, without losing time and the unnecessary motion of cannulating and decannulating (Fig. 19.5).

Ancillary Procedures

Rigottomy

Contracture of the mastectomy tissue is seen after infection, radiation, or scarring from previous surgery. Restoring a breast mound necessitates the release of scar bands



• **Fig. 19.8** Rigottomy, the percutaneous needle mesh release. Multiple small punctures can 3-D mesh-expand a tight scar and turn it into a recipient scaffold for fat grafts. The result is a larger, softer, construct with more fat and less scar. However, only micro-cavities created by smaller punctures preserve graft-to-recipient contact and succeed. Larger cuts create cavities where the graft will die from poor graft-to-recipient interface. It is therefore important to avoid over-meshing which might lead to necrosis and more scarring.

and a re-organization of the fibrous framework. Direct scar excision and open surgical release must be avoided since this will create cavities, which when grafted will lead to a graft that lacks a vascular recipient scaffold and a poor graft-to-recipient interface. Large cuts to release restrictive scars lead to cavities where the graft will die. To release and expand a scar without creating a cavity, the percutaneous needle mesh release or “Rigottomy” was developed by Dr. Rigotti. Using 18-gauge needles, or preferably solid 1.1-mm cutting needles, we inflict multiple nicks inside the contracted tissue to create a three-dimensional mesh that can expand to micro-cavities where the fat graft can revascularize and survive. However, it is important to realize that too much release will create cavities and also destroy the recipient scaffold. We are more liberal with Rigottomies if the patient has been well prepared with EVE as it increases the capillary density to preserve a vascular network despite more extensive meshing (Fig. 19.8).

Reverse Abdominoplasty and Fat Transfer (RAFT) Procedure

This percutaneous purse string suspension suture transfers as a flap without incision about 150 mL of perimammary tissue. This mushrooms up a breast mound and defines breast folds. We use a specially designed 35-cm long double-pointed needle with #2 PDS suture swaged 3 cm from one of the ends. The needle point is long and sabre-like flat to act as rudder that maintains a constant depth throughout its long passes in the subdermal plane.

Insertion of the RAFT Suture. Starting just under the mid-clavicle, we introduce the RAFT needle (Lipocosm, Miami, FL) towards the angle of Louis. We then steer it in the deep plane just above the sternum till the start of the medial mammary fold. From there on, we drive the needle to pursue a subdermal plane until the end of the lateral mammary fold. At this point, we pass the needle under the pectoralis and exit at the subclavicular entry site to complete the loop. Pulling and tightening the suture creates a purse-string effect and suspending the know to the clavi-pectoral fascia recruits a significant amount of peri-mammary tissue. Without an incision, this maneuver therefore brings into the mastectomy defect the combined equivalent of a reverse abdominoplasty flap and of a lateral thoracic flap. Passing the purse-string suture, however, is not enough. It is important to relieve tension and to create a wound injury interface for the tissues to heal and hold in their new position. We achieve this with a Rigottomy procedure that mesh expands the recruited abdominal and lateral thoracic tissue and, without making an incision, undermines the advanced tissues under the new fold (Fig. 19.9).



• **Fig. 19.9** The Reverse Abdominoplasty and Fat Transfer (RAFT) procedure: An incisionless flap tissue transfer that supplants fat transfer and is often the most significant tissue augmentation component. (A) We introduce the suture through a midclavicular puncture using a 35-cm long needle. We first direct it towards the periosteum of the sternum, then at the medial mammary fold, we guide it to a subdermal plane and thread along the epigastric and lateral thoracic tissues that will be recruited into the breast mound. At the end of the lateral mammary fold, we leave the subdermal plane and thread the needle under the pectoralis to emerge where it started and complete the loop. The multiple needle pricks caudal to the looped suture are required to divide the restraining fibers and to undermine the recruited tissue in order to achieve a tensionless advancement. (B) Pulling on the suture recruits as a flap about 100–150 mL and 2–7 cm of perimammary tissue to mushroom out a breast mound and define new breast folds. The suture is simply tied over the pectoralis muscle and the knot is buried. This maneuver is particularly helpful in breast reconstruction.

Case Examples

CASE 19.1

This 35-year-old patient underwent bilateral prophylactic nipple-sparing mastectomies and AFT to the pectoralis major muscles. This was followed by two sessions of AFT after EVE.

Preoperative markings for bilateral total mastectomy and immediate reconstruction with AFT are shown in [Case 19.1.1A](#). With the patient supine, the breast surgeon performed nipple-sparing bilateral mastectomies while the plastic surgeon liposuctioned the thighs. Then under direct vision the plastic surgeon meticulously grafted the exposed pectoralis muscle inserting thin ribbons of fat between the tweezed-apart muscle fibers to preserve optimal graft-to-recipient interface. Unrestricted by its excised fascia, the muscle expanded multiple folds without increase in the interstitial pressure. Thin layers of graft were also inserted in the submuscular plane, the pectoralis minor muscle, the interpectoral plane, the lateral thoracic fascia and the base of the mastectomy flaps. A total of 300 mL was grafted into each mastectomy defect site to replace the 450 g of mastectomy tissue. While approximating the mastectomy skin flaps it was important to avoid excess skin that would result in difficult to release creases and folds.

The immediate postoperative appearance is shown in [Case 19.1.1B](#). The patient has maintained some breast fullness. Three months later ([Case 19.1.1C](#)), the patient has small stable breast mounds from the surviving initial fat grafting. She then started EVE to expand the recipient site in preparation for the first post-mastectomy graft procedure.

[Case 19.1.1D](#) shows the EVE effect two weeks later, just before the first post mastectomy grafting session. Expansion generated an edema breast mound and a recipient scaffold for the liposuctioned fat grafts. 350 mL was grafted into each breast. [Case 19.1.1E](#) shows the EVE effect just before the second post-mastectomy grafting session. The second expansion generated an even larger tissue envelope and a larger edema breast mound recipient scaffold. For this third liposuction, we had to harvest from multiple convex donor sites to generate the 400 mL grafted into each breast.

One-year follow-up is shown in [Case 19.1.1F](#). The patient has recovered soft natural-looking breasts with no additional scars and has had liposuction improvement of her waistline. She has recovered essentially normal sensation over the entire *in situ* regenerated breast mounds.

Continued

CASE 19.1—cont'd



• Case 19.1.1

CASE 19.1—cont'd

• Case 19.1.1, cont'd

CASE 19.2

This 35-year-old patient underwent a left therapeutic mastectomy and a prophylactic right nipple-sparing mastectomy. She subsequently underwent three AFT procedures and the RAFT procedure at the time of the second AFT procedure.

Case 19.2.1A shows the patient a few weeks after the mastectomies before AFT or EVE. Two months later, after 3 weeks of EVE use, she presented for her first AFT session (Case 19.2.1B). Note that EVE is better at enlarging the more compliant tissue and that the transverse mastectomy scars remained tethered. These breasts will need to be expanded with Rigottomies. We grafted about 300 mL of fat through multiple needle-puncture entry sites all around the edema mound.

Three months later, after using EVE for two weeks, she presented for her second AFT session (Case 19.2.1C). This time we elected to augment the AFT with a RAFT procedure. The right photograph shows the liposuction donor sites and the course of the RAFT recruits abdominal flap tissue into the breast.

Case 19.2.1D shows the result three months after second AFT with RAFT tissue recruitment and fold definition. At this session, the patient underwent a third AFT for contour correction, nipple reconstruction and contour touch-ups.

Case 19.2.1E shows the appearance of her reconstructed breasts one year after her third reconstruction procedure. She has no new breast scars, and a body contour improvement from the liposuction. She feels totally restored and admits that her new breasts feel and look just like the original ones.



• Case 19.2.1

CASE 19.2—cont'd



• Case 19.2.1, cont'd

CASE 19.3

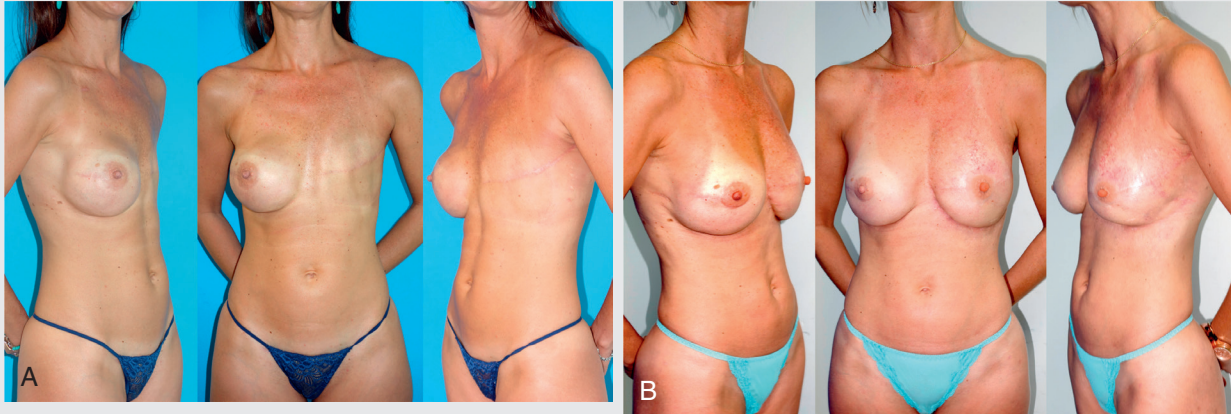
This 40-year-old patient had bilateral mastectomy and implant reconstruction. She presented after the reconstruction failed on the left radiated breast. The radiated and scarred tissues precluded a second implant attempt. Her abdomen was tight and she was reluctant to have the additional scars and the donor site of a latissimus flap. She decided to undergo EVE + AFT.

Case 19.3.1A shows the preoperative situation. The patient has a 525-mL implant on the right and no implant on the left radiated breast.

Treatment of the right, non-radiated breast: In the first session we removed her 525-mL implant through a lateral chest incision, and replaced it with a 265-mL implant after grafting the loosened thin mastectomy tissue plane. Three months later, due to AFT doubling of the thickness of her mastectomy flaps, she maintained the same breast size despite halving the size of her implant. During her second AFT procedure the implant was again halved to 130 mL. At another session, three months later, the implant was removed and the tissues were grafted to complete her totally autologous breast reconstruction. She was satisfied by that reconstruction and required no further procedures on that breast.

Treatment of the left radiated mastectomy: After four sessions of EVE + AFT, we ran out of donor sites and she still did not have a satisfactory breast mound. However, these successive AFT sessions served to reverse the radiation damage and to restore a near-normal soft tissue envelope that would readily accept an implant. Therefore, one year after we started her reconstruction process, at her fifth procedure, we were able to insert a 150-mL round implant, and with the help of a RAFT procedure, we recruited the required skin envelope for a symmetrical mound, defined new breast folds, and completed her AFT with implant chimeric reconstruction.

Case 19.3.1B shows her final appearance 6 months after the last procedure. On the right side, she required three sessions to convert her breast implant reconstruction to a totally autologous AFT reconstruction. The radiated left mastectomy required five AFT + EVE sessions plus a RAFT and an implant in order to achieve a satisfactory breast reconstruction.



• Case 19.3.1

CASE 19.4

This 33-year-old patient had bilateral nipple-sparing mastectomies and direct implant reconstruction. She had large mastectomy skin flap necrosis, particularly on the left, with loss of both implants. On presentation, she had a granulating wound on the left chest wall. She did not have localized fat excess and was not a good candidate for bilateral flap reconstruction. We therefore planned AFT to loosen the scars on the right side and a RAFT + AFT to close the wound defect on the left chest wall.

The blue dotted markings on the left in [Case 19.4.1A](#) outline the course of the RAFT suture that will be suspended on the pectoralis just below the clavicle. Black lines mark the puncture entry sites for the harvesting cannula in the abdominal donor site. Blue lines on the right, mark the grafting cannula entry sites.

[Case 19.4.1B](#) shows the one week postoperative result, with the left chest wall defect covered with a RAFT incisionless advancement flap that can accept more grafts in subsequent sessions.

[Case 19.4.1C](#) shows the preoperative view three months later and just prior to the second grafting session. The patient underwent EVE treatment for 3 weeks immediately prior to the procedure. The recipient sites are looser, larger, and more vascularized. However, the tethering scars did not expand as much and were loosened by needle mesh expansion with the AFT.

[Case 19.4.1D](#) shows the preoperative view another three months later and just prior to the third grafting session. The recipient site is even larger and was able to accept more grafts. The scars are less tethered and were ready to be completely smoothed out by further mesh expansion and AFT.

[Case 19.4.1E](#) shows the patient's appearance one year after her third AFT + EVE procedure. The scars have markedly improved and she has recovered totally autologous breast mounds that feel and look natural.



• Case 19.4.1

Postoperative Care and Expected Outcomes

Compared to the physiologic effects of flap transfer, breast reconstruction with AFT + EVE is reduced to a series of small outpatient procedures. The patients return to light level activities within a week.

Management of Complications

The most common complication is fat necrosis. It is the result of over-grafting, blob grafting, and cavity grafting. Small necrotic cysts will resorb with time, moderate-sized cysts can simply be aspirated, and larger cysts will lead to hard lumps that eventually calcify. Larger lesions from fat necrosis can be managed by resection and grafting again.

Necrotic tissue, a growth medium for bacteria, might lead to infection, ulceration and more tissue loss. Infection is rare, but tends to occur when there is tissue necrosis from failure to revascularize or from too extensive use of Rigotomies that destroy the vascular network required for tissue perfusion.

Fortunately, unless infection ensues, failure of graft to survive is a relatively benign complication treated by repeat fat grafting. In essence, if we fail to achieve a satisfactory breast mound in three sessions of fat grafting, we might have to graft once or twice more to complete the reconstruction.

Pneumothorax is a complication that still occurs in about 1% of the procedures. It is usually recognized in the recovery area by low oxygen saturation and treated with a chest tube.

Conclusions

We demonstrate that by adhering to well-established principles and techniques, total breast reconstruction with autologous fat transfer yields consistent results. In this chapter, an overview of preoperative patient selection, education, and surgical markings as well as the pearls necessary for achieving an optimal outcome are outlined.

Although many individual factors have been singled out as being responsible for graft survival, the final outcome depends upon a succession of chain-linked steps that need to be individually optimized.

Lastly, since the limit to success in mega-volume AFT is a recipient site large enough to accommodate the large graft amount, and since fat injection has limited ability to expand tissues, external vacuum expansion (EVE) is a necessary adjunct.

PEARLS FOR SUCCESS

- Fat harvesting is ideal with gentle low pressure, low airflow through multiple needle-puncture entry sites with criss-crossing passes of a fine 12-holed cannula after extensive tumescence of the donor sites to obtain a blood-free aspirate.

- Minimal lipoaspirate manipulation, simple gravity sedimentation, closed system for harvest, preparation and grafting.
- Small syringes to precisely deliver micro-ribbons at 1 mL per 10 cm of cannula excursion in separate tunnels.
- Sprinkler grafting: fine mist delivered through multiple needle-puncture sprinkler heads. Evenness through randomness.
- Less is more. Determine the capacity of the recipient site and do not exceed it. Avoid the common over-grafting mistake.
- Prepare the recipient with EVE to accept more grafts and to generate the required skin envelope.
- Select well-informed patients who will be compliant with EVE and understand that reconstructing a breast with fat grafts takes time and patient participation.
- Take advantage of the ancillary procedures such as Rigotomies to release restrictive scars and RAFT to recruit perimammary tissue and define new breast folds.
- Postoperatively protect and nurture the fresh grafts to prevent volume loss with an adhesive bra splint or with EVE at a steady low pressure.

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20

Fat Grafting as an Adjunct Procedure in Breast Reconstruction

ORIANA COHEN AND NOLAN S. KARP

Introduction

Autologous fat grafting to the breast is a widely used and accepted adjunct in breast reconstruction today. The technique involves harvest of fat from patient-specific donor sites, fat processing, and subsequent transfer in order to improve depressions and step-offs, which may exist at the junction of the reconstructed breast and chest wall, or following lumpectomy.

First introduced in 1895 by Czerny, fat grafting was utilized when an excised lipoma was transferred to the breast to reconstruct a breast defect. In the early 20th century, fat grafting gained momentum, however the practice of fat grafting did not become popular until the 1980s. In 1987, however, the American Society of Plastic Surgeons (ASPS) banned autologous fat grafting of breasts over concern for future cancer surveillance in the setting of fat necrosis.¹ In 2007, the ASPS established a task force to re-evaluate the potential hazards of fat grafting, and concluded that radiographic technology could distinguish grafted fat from potentially dangerous lesions. Therefore, the ASPS Fat Graft Task Force lifted the ban on fat grafting in 2009 when it determined from a limited number of studies that there appeared to be no interference with breast cancer detection.²

Numerous recent studies have demonstrated the regenerative capabilities of transferred fat, including improved angiogenesis, dermal thickness and elasticity, and radiation-induced fibrotic changes.^{3–5} For this reason, fat grafting has become a useful adjunct and workhorse in lumpectomy defects as well as autologous and implant-based breast reconstruction, particularly in radiated fields.

Successful fat grafting requires close attention to the recipient site compliance and capacity, as well as thorough fat harvesting, processing, and delivery technique. Here, we discuss the current indications for autologous fat grafting as an adjunct in breast reconstruction and review pertinent aspects of the preoperative patient evaluation. We describe

operative techniques including donor-site selection, fat harvesting and processing. We conclude with several case examples and a review of postoperative complications and their management.

Indications and Contraindications

Autologous fat grafting is indicated for the correction of contour deformities and step-offs following autologous or implant-based post-mastectomy breast reconstruction, which often occur at the periphery of the breast reconstruction. Transferred fat may also be utilized to improve the contour of lumpectomy defects. However, established and safe indications for autologous fat grafting vary by breast reconstruction modality.

Implant-Based Reconstruction

In implant-based reconstruction, thin mastectomy flaps may lead to visible implant borders or implant rippling. Fat grafting may be utilized in these cases to camouflage implant rippling or smoothen the transition superiorly between the native chest wall and the implant. Fat grafting is commonly first performed at the time of tissue expander-to-implant exchange. However, in cases of direct implant reconstruction, fat grafting is often performed as a secondary procedure. It should be noted that patients may require several fat-grafting procedures in order to achieve desired results.

Autologous Reconstruction

In autologous reconstruction, fat can be used to smoothen the transition (or “step-off”) between the flap and chest wall. Additionally, fat grafting has been described to augment the overall volume of smaller flaps or failed flaps. While fat grafting is more frequently performed approximately 3–6 months following flap transfer, some surgeons opt to fat graft potential flaps prior to free tissue transfer.

Lumpectomy Defects

Fat grafting is a useful adjunct in the correction of contour abnormalities and breast asymmetry following lumpectomy. In the case of breast conservation therapy, a lumpectomy (or partial mastectomy) may be performed with adjuvant radiation therapy, where up to 30% of patients report dissatisfaction with aesthetic results. While radiated lumpectomy defects can represent a hostile environment, transferred fat has been shown to improve breast contour, as well as skin and soft tissue quality following radiation therapy thereby improving aesthetic outcomes. Again, patients may require more than one fat-grafting procedure in order to achieve desired results.

The only absolute contraindication to autologous fat grafting in breast reconstruction is lack of donor-site availability, which may be seen in an underweight patient. Additionally, patients with medical co-morbidities placing them at operative risk should not be offered fat grafting (Box 20.1).

Preoperative Evaluation

A thorough history and physical exam is obtained from the patient. History should include medical co-morbidities and oncologic history, including prior surgery or radiation treatment. Physical exam involves analysis of the defect and preoperative patient photographs. Additionally, three-dimensional imaging is a useful tool in helping the surgeon determine the amount of fat to be grafted. In cases of unilateral reconstruction, the contralateral breast can be used as a reference point.

The physical exam should also include evaluation of potential donor sites, primarily the abdomen, flanks, saddlebag region, and medial thighs. The site selected is based on both patient preference and ease of harvest.

The risks and benefits of fat grafting should be discussed with the patient and informed consent obtained. Risks

include but are not limited to bleeding, seroma, infection, scarring at access incisions, continued contour abnormalities, fat resorption, and need for implant replacement or future operation.

Surgical Techniques

The three critical steps of autologous fat grafting are fat harvest, processing, and grafting. There are various techniques for each step, all with the aim of preventing adipocyte trauma and maximizing cell viability (Fig. 20.1).

Timing

A well-vascularized recipient bed is critical in maximizing adipocyte viability. Optimization of recipient conditions includes waiting 3 months following prior breast surgery in order to minimize edema and allow for better demarcation of the contour defect, as well as allow for revascularization. Similarly, patients are often instructed to wait 6 months in between fat-grafting procedures to allow for resolution of edema and adequate wound bed revascularization.

Donor-Site Selection

The location of fat deposits in the body varies between patients. The plastic surgeon should carefully evaluate the patient and have a conversation with the patient regarding possible donor sites. As mentioned previously, these potential donor sites include the abdomen, flanks, trochanteric or “saddlebags” region, and medial thighs.

Fat Harvesting

Prior to harvesting of fat, the proposed area for harvest is infiltrated with tumescence containing lidocaine and epinephrine diluted in lactated Ringer's or normal saline. Tumescence serves to hydrodissect the tissue planes and increases the volume of the target fat layer, thereby facilitating fat harvest. It additionally helps to decrease postoperative pain and ecchymosis.

Currently, the most commonly utilized techniques for fat harvesting include vacuum aspiration and syringe aspiration. High vacuum pressures of conventional liposuction and power-assisted liposuction may disrupt adipocyte cell structure. Instead, maintaining low negative-pressure lipoaspiration is preferred and may yield fat faster than syringe aspiration, especially useful when a large volume of fat is needed.

Additionally, cannula size may affect the viability of harvested fat. Large-bore cannulas may reduce the incidence of cell rupture and better preserve tissue architecture. In the Coleman technique for fat harvesting, a 3-mm blunt-edged 2-hole cannula is connected to a 10-mL syringe and fat is suctioned manually by withdrawing the plunger to create gentle negative pressure.⁶

• BOX 20.1 Indications and Contraindications of Autologous Fat Grafting in Breast Reconstruction

Established Indications

Implant-Based Reconstruction

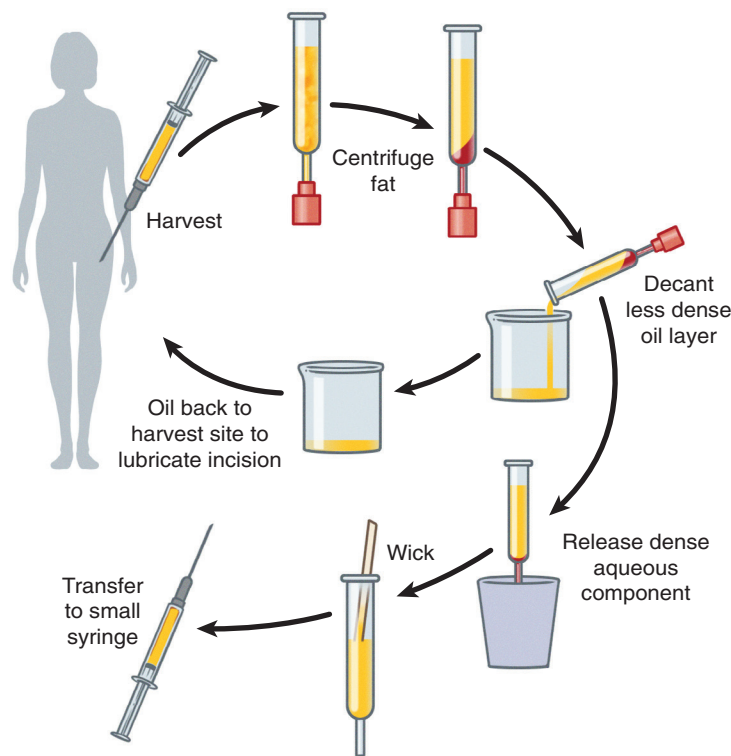
- Mastectomy skin flap irregularities
- Step-off at implant border
- Implant rippling

Autologous Reconstruction

- Step-off at flap border
- Depression from fat necrosis
- Augmentation of flap volume
- Radiation fibrosis

Established Contraindications

- Lack of donor site availability
- Serious medical comorbidities



• **Fig. 20.1** Fat-grafting process. Fat is harvested, processed via centrifugation, blood and tumescent fluid decanted, and oil removed prior to transfer.

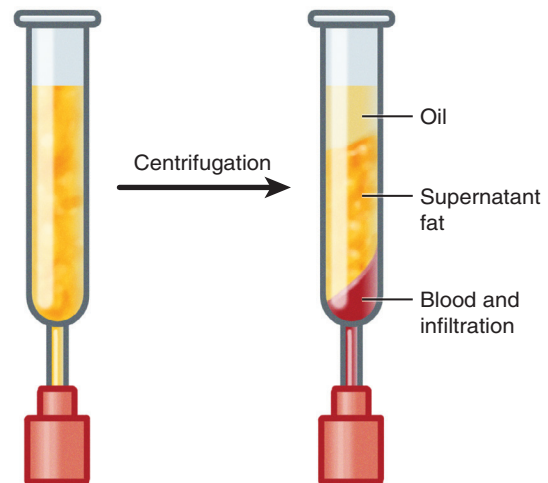
Fat Processing

Fat processing is necessary because the lipoaspirate contains not only adipocytes but also collagen fibers, blood, and extracellular debris, which can incite an inflammatory response. The various described fat processing techniques include gravity separation, centrifugation, and Telfa processing (Covidien, Minneapolis, MN).

In centrifugation, the lipoaspirate is loaded into 10-mL syringes and centrifuged at ~3000 rpm for approximately 3 minutes. After centrifugation, three layers demarcate: the most inferior portion contains blood, plasma, and local anesthesia, which are drained from the base of the syringe. The middle layer is comprised of adipocytes, which are ultimately grafted. The top layer is a lipid-rich layer that can be poured off and is then wicked with cotton gauze for further removal of oil (Fig. 20.2).

Some surgeons support the use of centrifugation, others feel it lyses adipocytes and compacts the graft, reducing the possibility of fat-to-recipient interaction, and instead favor separation by simple gravity sedimentation.⁷

Conversely, in the Telfa rolling technique, the harvested fat is poured onto Telfa gauze and rolled with the back of a scalpel until the tumescence and oil have been absorbed. In a study out of our institution, centrifugation was found to produce fat with the greatest number of progenitor cells, whereas Telfa-processed fat produces fat with greater cytokine secretion and fat persistence⁸ (Fig. 20.3).

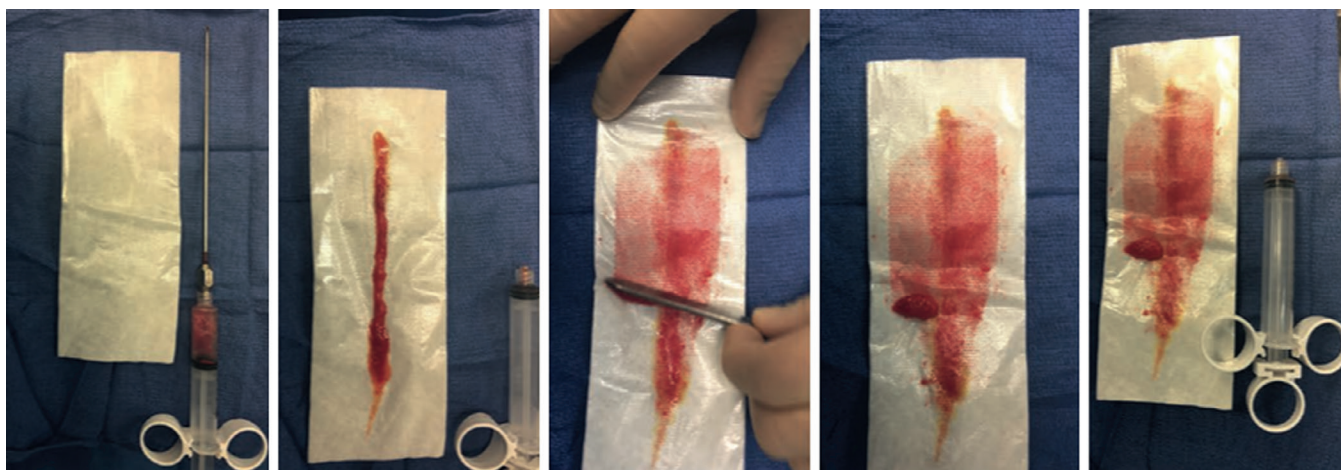


• **Fig. 20.2** Fat processing via centrifugation.

Fat may additionally be processed by filtration and washing. Devices such as the Revolve System (LifeCell; Bridgewater, NJ) have been developed, which facilitate fat harvest using a combination of filtration, mechanical washing for collagen strand removal, and a port for syringe extraction (Fig. 20.4).

Fat Injection

Principles of fat injection are based on optimizing recipient-site vascularity for increased fat survival. Dr. Coleman



• **Fig. 20.3** Telfa rolling method. (From Canizares O Jr, Thomson JE, Allen RJ Jr, et al. The effect of processing technique on fat graft survival. *Plast Reconstr Surg.* 2017;140(5):933–943.)



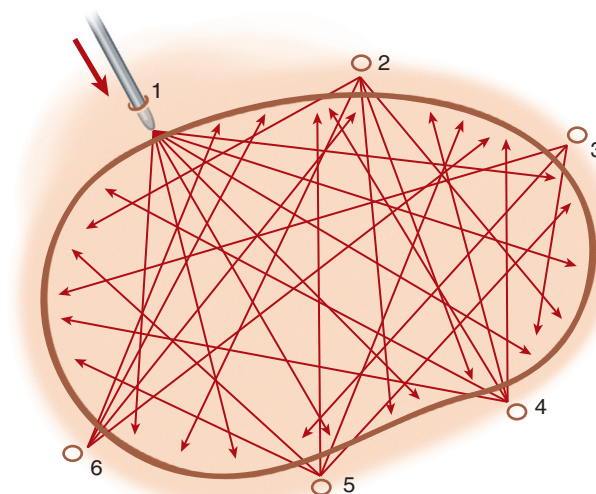
• **Fig. 20.4** The Revolve System.

purports the use of fat in the micro-droplet form, injecting less than 0.1 mL of graft per centimeter of cannula excursion.⁹ And in fact, fat reinjection in multiple small-volume aliquots is preferred. A small-bore cannula is inserted into the planned area of grafting and small aliquots are distributed during withdrawal of the cannula, fanning out the fat in varying depths to avoid excessive interstitial pressure and adipocyte crowding (Fig. 20.5).

Authors' Preferred Technique

The patient is marked while standing in order to highlight the areas of contour irregularity. The defect borders should be marked in order to facilitate intraoperative identification, where the supine position may obscure depressions and step-offs. The amount of fat needed for grafting should be estimated and corresponding donor sites marked. If concomitant capsulorrhaphy is to be done, the regions of interest are additionally marked.

The patient is brought into the operating room and placed in the supine position. Deep vein thrombosis (DVT)



• **Fig. 20.5** Fat grafting. Lattice-like framework pattern of injection. The fat is injected through multiple small stab wounds in a lattice-like pattern. (Adapted from Nahabedian MY, Neligan PC, eds. *Plastic Surgery.* 4th ed. Vol 5. © 2018, Elsevier Inc.)

prophylaxis is initiated with sequential compression devices on the bilateral lower extremities. General anesthesia is induced. Following this, the planned donor sites are prepped using Chloraprep (BD; Franklin Lakes, NJ) and draped in standard sterile fashion. Access incisions for fat harvest are planned in natural skin creases in order to maximize cosmesis and allow for maximal criss-crossing of tunnels for fat placement. Tumescence solution containing 1 L of Ringer's lactate, 20 mL of 2% lidocaine and 1 mL of 1:1000 epinephrine is infused into the planned area of liposuction through these access incisions. After waiting an adequate time for the hemostatic effects of tumescence to take effect, liposuction is performed using a 3.7-mm liposuction cannula and the Revolve System, which harvests the fat and processes the fat via filtration, gravity separation, and washing of plasma and debris. The fat is then transferred into 6-mL syringes for injection directly from the Revolve System.

Prior to grafting, scar contracture release is often necessary using the Rigottomy technique. If doing so, particular attention must be paid to the underlying implant or flap pedicle in order to prevent injury to these critical structures.

Fat is then grafted into depressions and contour irregularities using multiple tunnels in a crosshatch fashion. We utilize a blunt-tipped cannula attached to a 6-mL syringe

to inject small volumes of fat during the withdrawal phase of cannula movement, the goal being a lattice-like pattern of fat injection. Injection is performed in both the sitting and supine positions. Once an adequate amount of fat has been grafted, access incisions are closed with a 5-0 plain gut suture (Ethicon; Somerville, NJ) and dressed with Steri-Strips (3M; Maplewood, MN). Pressure garments are then used at donor sites in order to prevent seroma formation.

Case Examples

CASE 20.1

Fat Grafting Following Implant-Based Reconstruction With Step-Off

A 52-year-old patient with left breast adenocarcinoma and bilateral breast atypical ductal hyperplasia underwent bilateral nipple-sparing mastectomy (mastectomy specimen weights: 142 g, 150 g) and placement of 213-cc smooth round silicone implants with fenestrated AlloDerm. Eight months postoperatively, the patient reported a slight upper pole step-off between the chest wall and the implants (more pronounced on the right) for which she wished to undergo fat

grafting for improved contour. Following release of scar contractures using the Rigottomy technique, 48 mL of fat were injected into the right breast and 36 mL into the left breast in both the supine and sitting position. As demonstrated in [Case 20.1.1](#), at 13 months postoperatively, the transition between the chest wall and the implant is smoothed out and symmetric, and the patient is pleased with her results following a single fat-grafting procedure.



• Case 20.1.1

CASE 20.2**Fat Grafting Following Lumpectomy**

A 52-year-old patient presented for plastic surgery evaluation 3 months after undergoing left breast lumpectomy for a myxoid fibroadenoma with atypia, concerned with a noticeable deformity secondary to volume deficiency of her left inferolateral breast. Repeat examination 1 year postoperatively demonstrated a persistent defect and contour abnormality, for which the patient underwent fat grafting from the lateral thighs.

Following scar contracture release by Rigottomy technique using an 18-gauge needle, 39 mL of fat was grafted into the left inferolateral breast deformity. As demonstrated in [Case 20.2.1](#), at four months postoperative, the patient shows dramatic improvement in the contour deformity with restoration of symmetry and a natural breast shape after a single fat-grafting procedure.

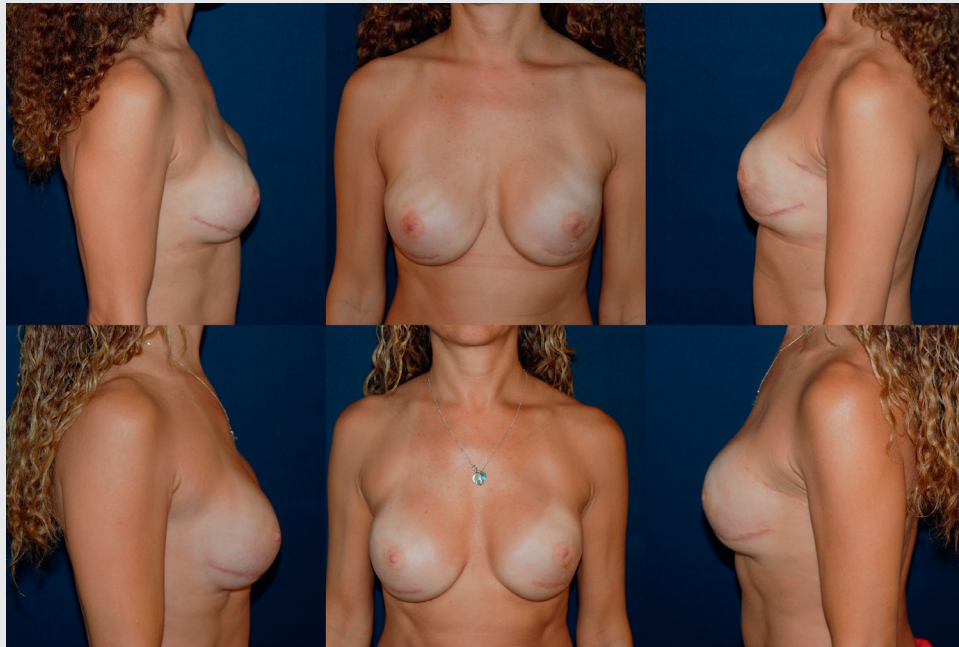


• Case 20.2.1

CASE 20.3**Fat Grafting After Implant-Based Reconstruction to Correct Rippling**

A 45-year-old patient with left breast cancer who underwent nipple-sparing mastectomy and direct implant reconstruction with style 20, 400-mL implants. Six months after the surgery, the patient returned complaining of upper pole rippling bilaterally and step-off on the right. The patient was taken to the OR and liposuction was performed of the abdomen and

thighs into the Revolve machine. Approximately 250 cc of fat was obtained. The fat was washed twice with warmed Ringer's lactate. 42 cc were injected in the right upper pole of the breast and 24 cc were injected in the left upper pole using 3-cc syringes. As seen in [Case 20.3.1](#), nine months postoperative, the patient shows significant improvement.

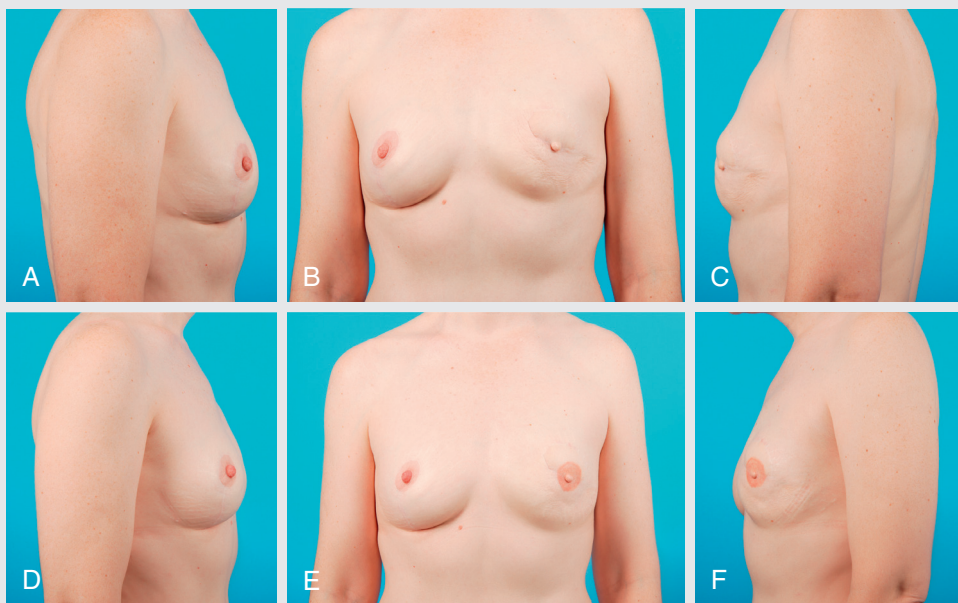
CASE 20.3—cont'd

• Case 20.3.1

CASE 20.4**Fat Grafting for Inadequate Flap Volume**

A 40-year-old patient with left breast cancer who underwent left skin-sparing mastectomy and microvascular muscle-sparing TRAM flap. The flap had inadequate volume compared to the right side. 3-D scan confirmed that there was 90 cc

difference in the volume between the two breasts. The patient underwent 178 cc of fat injection into the left breast using a Coleman type technique. [Case 20.4.1](#) shows much-improved symmetry at 2 years postoperative.



• Case 20.4.1

Postoperative Care and Expected Outcomes

Postoperatively, patients are instructed to minimize arm movement for approximately one week. A loose supportive bra is provided for the chest and a compression garment for the donor site. Patients are educated that postoperative swelling is greatest in the first 2 weeks postoperatively, but may persist for several months.

If several rounds of fat grafting are planned, or a persistent contour deformity remains after resolution of swelling, patients are educated that additional fat grafting may be performed as early as 6 months postoperatively. There are no changes in routine postoperative mammography or breast oncology follow-up.

Management of Complications

Fat resorption, or volume loss, is frequently seen and quoted as 30%–70% within a year. The majority of the volume change occurs within the first three postoperative months, however it may continue up to 6 months postoperatively. Graft survival varies with methods used to harvest, process, and graft the fat. Additionally, there are recipient factors at play, with greater fat survival when grafted into well-vascularized beds. Other complications include fat necrosis and oil cyst formation, cited in up to 15%.¹⁰ These generally form in areas where fat is inadequately distributed or overfilled. Oil cysts can be drained in the office under local anesthesia. Larger areas of fat necrosis can be removed with liposuction or Riggotomy and any resultant contour abnormalities later fat grafted.

Abnormal mammographic findings, namely calcifications, may be identified on mammography following fat grafting and, if suspicious, should be biopsied. It should be noted that preoperative mammography is important as a baseline to which post-fat-grafting mammograms may be compared.

Additional postoperative complications include infection and persistent swelling. The effect of postsurgical infection on the viability of grafted fat has been equivocal. Secondly, persistent swelling beyond two months may signify underlying cyst or fat necrosis for which the patient should be further evaluated.

Concerns regarding the oncologic safety of autologous fat grafting have been raised. However, several studies, including an analysis of 829 breast reconstructions from our institution, have demonstrated no increased risk in local breast cancer recurrence or distant tumor metastasis.^{11,12}

Lastly, an additional concern is difficulty in distinguishing fat necrosis from breast malignancy on subsequent breast imaging. However, recent studies have suggested that

scarring and masses requiring biopsy were more frequently found in patients following breast reduction compared to fat transfer. Additionally, BI-RADS scores were found to be higher in patients following breast reduction compared to fat grafting.¹³

Secondary Procedures

Patients who undergo autologous fat grafting may necessitate secondary procedures due to incomplete primary correction or fat resorption. In fact, up to 55% of patients undergo several fat-grafting procedures to treat residual contour anomalies, depressions, and step-offs.¹⁴ As previously mentioned, additional fat grafting may be performed as early as 6 months postoperatively, and may be repeated as needed to achieve the desired breast contour. Of note, patients with a history of radiation therapy are especially prone to requiring more than one fat-grafting procedure due to the poorer compliance of the soft-tissue envelope, and postulated higher rates of fat resorption as compared to patients without a history of radiation therapy.¹⁵

Additionally, patients who undergo fat grafting may subsequently require aspiration of oil cysts or biopsy and/or excision of areas of fat necrosis. Fat necrosis can be confused with carcinoma, both clinically and radiographically. The myriad clinical features of fat necrosis range from a nonpalpable mass to a palpable mass concerning for cancer. Moreover, the radiographic presentation of fat necrosis can similarly vary from a benign oil cyst to a spiculated mass. Mammography will often reveal a radiolucent mass; however, concerning clustered or spiculated calcifications may be present. Additionally, sonographic features of fat necrosis range from solid nodules with posterior shadowing to concerning complex or irregular masses.¹⁶ In one study of 167 breasts, 31.7% of breasts underwent some form of additional breast imaging following autologous fat grafting, of which 7.5% required biopsy.¹⁷ For these reasons, the importance of a clinically palpable lesion or suspicious imaging finding following autologous fat grafting cannot be underscored enough.

Conclusions

As breast reconstruction techniques have been finessed, so too have patients' aesthetic expectations evolved. Autologous fat grafting is a powerful tool for helping the reconstructive breast surgeon achieve aesthetic results in a safe and effective manner in both autologous and implant-based reconstructions as well as following lumpectomy with and without postoperative radiation therapy. Current research efforts aim to compare harvesting, processing, and grafting practices in order to maximize the viability of transferred fat and further refine current practices.

PEARLS FOR SUCCESS

- Autologous fat grafting is a useful tool in the correction of contour deformities following implant-based and autologous post-mastectomy reconstruction, as well as for partial mastectomy/lumpectomy defects.
- The only absolute contraindication to autologous fat grafting in breast reconstruction is lack of adequate donor sites.
- Transferred fat has regenerative capabilities including angiogenesis, increased dermal thickness and elasticity, and improved radiation-induced fibrotic changes.
- Successful fat grafting requires close attention to the recipient site capacity as well as careful fat harvesting, processing, and delivery technique.
- Up to 55% of patients undergo more than one fat grafting procedure to treat residual contour anomalies, depressions, and step-offs.
- Complications are minor and include fat resorption, fat necrosis, and oil cyst formation.
- Abnormal mammographic findings, namely calcifications, may be identified on mammography following fat grafting and, if suspicious, should be biopsied.
- Existing studies to date demonstrate no increased risk in local breast cancer recurrence or distant tumor metastasis following autologous fat grafting.

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21

Nipple–Areola Complex Reconstruction

LEE L.Q. PU AND DAVID E. SAHAR

► Introduction

Nipple–areola complex (NAC) reconstruction can be an important part of breast reconstruction and will definitely add an aesthetic component of breast reconstruction. Without NAC reconstruction, it usually gives the impression that the breast reconstruction has not been completed. Therefore, NAC reconstruction can be an important component of breast reconstruction and should be considered an important part of any type of breast reconstruction.

Although a number of techniques for NAC reconstruction have been described in the literature, only two methods are commonly used by most plastic surgeons and have frequently been studied.^{1–4} One is the skate flap in which the nipple is reconstructed by a local flap like a skate and the areolar circle is reconstructed with a full-thickness skin graft. The C-V flap was described as a modification of the skate flap to reduce the need for skin grafting the areola. It is a random “flap-on-a-flap,” where the “C” portion of the flap derives its blood supply from the “V” flap, which is a random flap. The areola circle after a C-V flap reconstruction can be tattooed later. Each type of NAC reconstruction may be equally good based on the patient’s selection and the surgeon’s experience and preference. In general, NAC reconstruction can be performed based on an autologous breast reconstruction since there is adequate tissue for such a reconstruction with higher patient satisfaction. However, for an implant-based reconstruction, the NAC reconstruction may present a challenge because there is lack of tissue over the breast implant for such a reconstruction with the lowest patient satisfaction.⁴ In addition, the scar pattern over the previous breast reconstruction may also impact the location and outcome of NAC reconstruction.

In this chapter, the skate flap with a skin graft and the C-V flap, the two most commonly performed NAC

reconstructions, are described. The authors have also added their modifications to each type of NAC reconstruction so that a better reconstructive outcome can be achieved. Each surgical technique will be described in detail and several refinements are also described.

Indications and Contraindications

NAC reconstruction is indicated for almost all patients after their autologous or implant-based breast reconstruction. In general, the timing of such a reconstruction is about 2–3 months after initial or secondary breast reconstruction once no major revision for the reconstructed breast in terms of its size and shape is needed. If radiation has been performed on the reconstructed breast we prefer to postpone the NAC reconstruction for about a year once the radiation damage to the breast skin has been resolved so that overall complication of NAC reconstruction, such as delayed wound healing, can be minimized. If healing of the incision or radiation changes over the reconstructed breast has not been relatively mature or resolved, the timing of NAC reconstruction can be further postponed.

Preoperative Evaluation and Special Considerations

One of the major issues is determining whether the patient will have adequate soft tissue over the reconstructed breast that can be used for a nipple reconstruction. This can be done with a pinch test. If the thickness of the soft tissue over the reconstructed breast is less than 0.5 cm, which can be a common finding for implant-based breast reconstruction, limited projection after any type of NAC reconstruction may be expected. For bilateral nipple reconstructions, very often the location of the scar over the reconstructed

breast can be problematic because it may interfere with the determination of new nipple position over the reconstructed breast. Sometimes the design of the new nipple position can be above or below the scar to avoid a high-ride look to the reconstructed nipple and the design of a local flap for NAC reconstruction can be modified.

For unilateral nipple reconstruction with consideration of where the new nipple should be on the reconstructed breast, obviously it will be based on the measurement in reference to the breast mound of the reconstructed breast and also to the contralateral side of the breast. Ideally, the new nipple position should be at the highest peak of the breast mound. However, it also can be placed higher or lower than the peak of the breast mound although the lower placement of the new nipple position is preferred to avoid a high-ride position of the reconstructed nipple.

When planning a new NAC reconstruction, attention should be made during the preoperative evaluation to make sure such a local skin flap used for nipple reconstruction can be elevated safely and healed without delay. If a skin graft is needed, it can be harvested from any location in which the patient has a scar. Very commonly, the authors prefer to harvest a full-thickness skin graft from the suprapubic area, the lateral aspect of abdominal incision, or the inguinal area.

Surgical Technique

Relevant Surgical Anatomy

The blood supply to the reconstructed nipple from local skin over the reconstructed breast is from the subdermal plexus regardless of the design for each type of reconstruction. Since the skin flap over the reconstructed breast is elevated to reconstruct the nipple, attention should be made to make sure that the flap is based wide enough to receive adequate blood supply so that the flap can survive after its elevation and closure. This is especially important for an implant-based reconstruction since the local skin flap should be elevated wider and thicker enough for nipple reconstruction. In addition, the flap should incorporate as much local subcutaneous tissue and/or dermis as possible to reconstruct an adequate-sized nipple since the reconstructed nipple can shrink up to 50% after reconstruction. It is important to base the skin flap away from the scar or the area with previous radiation injury.

Operative Technique

The Skate Flap

A skate flap is designed according to the symmetry and also the location of the scar over the reconstructed breast (Fig. 21.1A). The size of the flap is designed between 1 and 1.5 cm and the diameter of the new areolar circle is 3.8 or 4.8 cm depending on the expected final size and projection of the reconstructed nipple (Fig. 21.1B). The upper third of the skin within the designed areolar circle is

de-epithelialized (Fig. 21.1C). A skin-only flap from both sides is then quickly raised with knife to the line on each side when a true skin flap with adequate fat is carefully railed with scissors. Within the base of the flap, each triangular shape of flap is then elevated and attention is made to carry adequate fat along with each skin flap (Fig. 21.1D). Each side of the skin flap is approximated in the volar aspect of the reconstructed nipple and the posterior skin flap is then approximated anteriorly to join the valor approximation. At this point, excess skin in each corner is marked (Fig. 21.1E) and precise de-epithelialization is then performed (Fig. 21.1F). In this way, additional healthy vascularized tissue can be inserted to add projection of the reconstructed nipple (Fig. 21.1G).

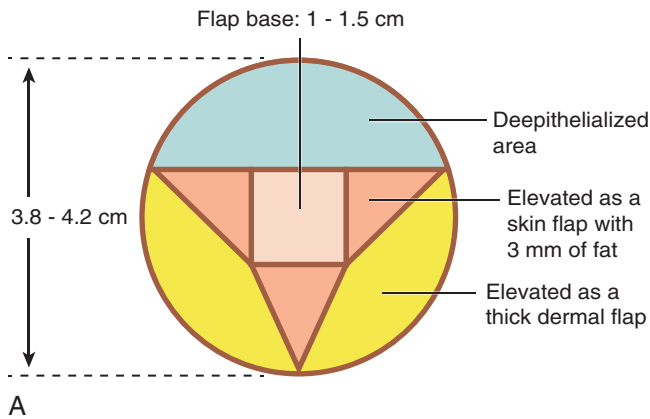
A 38- or 42-mm cookie cutter is used to outline the full-thickness skin graft site. A full-thickness skin graft is then harvested and defatted (Fig. 21.1H). Its incision site is closed in two layers accordingly. The skin graft is then placed through the reconstructed nipple to form the new alveolar circle and closed in both inner and outer circles with absorbable suture (Fig. 21.1I). At the end of the procedure, the reconstructed nipple is protected with a nipple protector and the areolar skin graft is immobilized with Steri-Strips (Fig. 21.1J).

If NAC reconstruction is performed over an implant-based reconstruction, derma-fat graft can be added to the reconstructed nipple before its final closure to add projection for possible better long-term results. It can be conveniently harvested during a skin graft harvest for areolar reconstruction. Within a planned excision of a full-thickness skin graft, a derma-fat graft (4×3×3 mm) can be made first after de-epithelialization (Fig. 21.2A). In general, two pieces would be needed for each nipple reconstruction and more optimal projection can be achieved with this approach (Fig. 21.2B,C). In addition, the design of a skate flap can also be orientated inferiorly to accommodate the location of a mastectomy scar (Fig. 21.3).

The C-V Flap

The C-V flap is a random “flap-on-a-flap,” where the “C” portion of the flap receives its blood supply from the “V” flap, which in itself is a random flap (Fig. 21.4A). This increases the length-to-width ratio to about 2:1. The pedicle of the flap should be away from the mastectomy scar to maximize subdermal capillary perfusion pressure to reach the most distal aspect of the C flap. Nipple position is marked as described previously. The C flap measures about 1–1.5 cm, while the entire length of the V wings is 4–4.5 cm. The length of the C flap should not exceed its base length receiving blood supply from the V flap (Fig. 21.4B). The reconstruction should be planned at least 25% larger to account for later loss of volume and projection.

An incision is made with a knife through the dermis followed by fine tenotomy scissors to raise the flaps. Subcutaneous adipose tissue is included in the flap to minimize damage to the subdermal plexus. Extra subcutaneous fat is recruited at the pedicle of the V flap to increase volume, if



• **Fig. 21.1** Skate flap. (A) Schematic diagram showing the design of the skate flap described in this chapter. (B) Intraoperative view showing the design of the skate flap. (C) Intraoperative view after de-epithelialization and incision of the skate flap. (D) Intraoperative view showing completion of elevation of three skin flaps and approximation ventrally for the nipple reconstruction. (E) Intraoperative view showing completion of initial closure of all three skin flaps to reconstruct the nipple. Two marked areas (labeled in dark blue) of the excess skin flap tissue will be de-epithelialized and added to the reconstructed nipple after final closure. (F) Intraoperative view showing completion of de-epithelialization of excess skin flap tissue. This will be added to the reconstructed nipple after final closure.

Continued



• **Fig. 21.1, cont'd** (G) Intraoperative view showing completion of the skate flap nipple reconstruction. (H) Intraoperative view showing completion of a prepared full-thickness skin graft for the areolar circle reconstruction. (I) Intraoperative view showing completion of the skate flap nipple reconstruction and areolar circle skin grafting. (J) Intraoperative view showing immobilization of the reconstructed nipple and areolar circle with a self-made nipple protector and Steri-Strips.



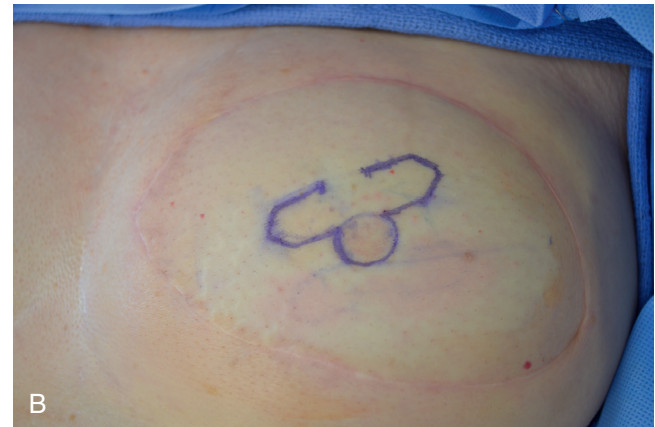
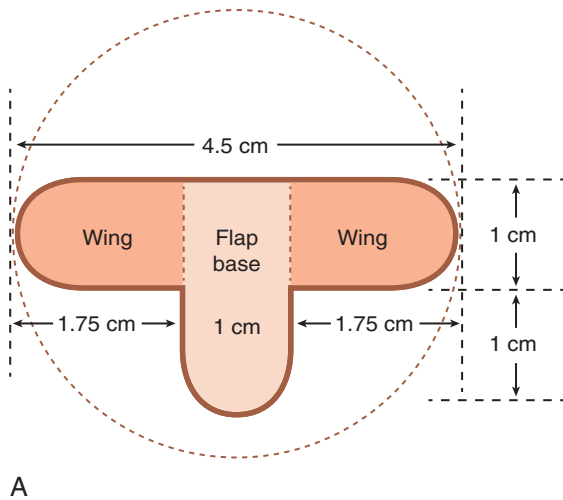
• **Fig. 21.2** (A) Intraoperative view showing two areas that will be harvested for derma-fat grafts. (B) Intraoperative view showing two harvested and prepared derma-fat grafts.



• **Fig. 21.2, cont'd** (C) Intraoperative view showing good projection of the reconstructed nipple after insertion of two derma-fat grafts.

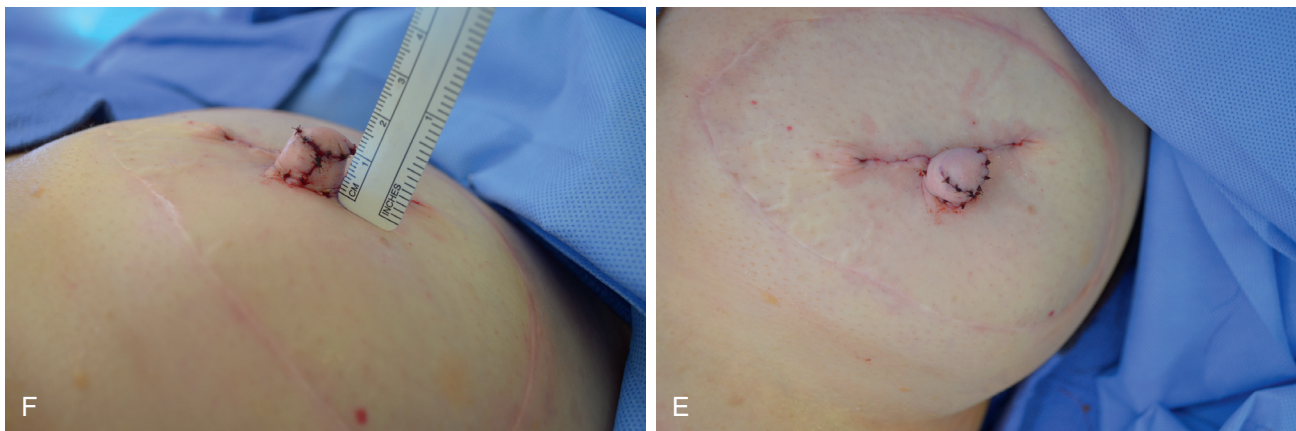


• **Fig. 21.3** Intraoperative view showing how the design of a skate flap can be orientated inferiorly to accommodate the location of a mastectomy scar.



• **Fig. 21.4** C-V flap. (A) Schematic diagram showing the design of the C-V flap described in this chapter. (B) Intraoperative view showing the design of the C-V flap. (C) Intraoperative view showing completion of elevation of three skin flaps. (D) Intraoperative view showing completion of the preliminary closure of three skin flaps for the nipple reconstruction.

Continued



• **Fig. 21.4, cont'd** (E) Intraoperative view showing completion of the nipple reconstruction with the C-V flap. (F) Intraoperative view showing good projection of the reconstructed nipple after insertion of two dermal grafts.

possible (Fig. 21.4C). Once all flaps are raised, the V flaps are wrapped around the C flap and the skin is closed in layers (Fig. 21.4D). The dermis is closed using 4-0 Vicryl suture and the remaining skin is closed using 5-0 monocryl and 5-0 chromic sutures (Fig. 21.4E). Tissue handling is important using skin hooks and the surgeon should be mindful of implant under the flap, if there is one, to avoid capsule violation and implant exposure/puncture. Autologous or allogeneic dermal graft can be inserted to maintain the nipple size and projection (Fig. 21.4F).

Postoperative Care and Expected Outcomes

For the skate flap, the nipple protector and Steri-Strips placed in the operating room can be removed in 7 days. After that, the reconstructed nipple and areolar skin graft

is covered with a daily Xeroform dressing for two more weeks. The complete healing of NAC reconstruction can be achieved in 2–3 weeks. In general, the nipple size will shrink up to 50%. However, after four months the reconstructed nipple will become more stable and the size and projection can be maintained. In general, the pigmentation formed from a well-healed areolar skin graft site may be adequate for most Caucasian patients and no further tattooing is needed for a reconstructed NAC in this population. However, in Asian or dark-skinned patients, tattooing of a reconstructed NAC may still be needed.

C-V flap care is similar, where the nipple protector and Steri-Strips placed in the operating room can be removed in 7 days. The areola is tattooed 4–5 months postoperatively. Alternatively, the areola can be skin grafted during the nipple reconstruction procedure, especially in cases of bilateral breast reconstruction.

Case Examples

CASE 21.1

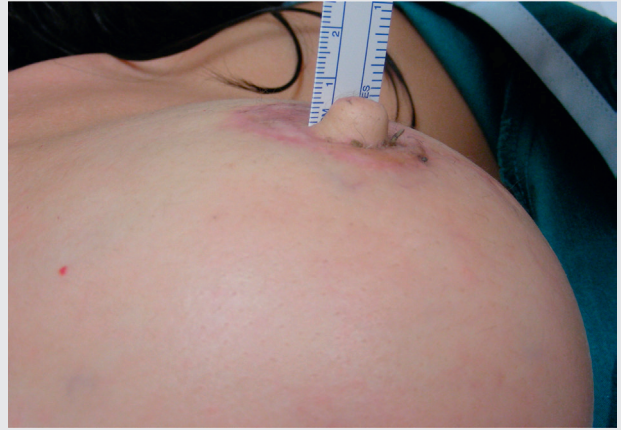
A 39-year-old white patient had successful bilateral breast reconstructions with silicone implant (immediate, two-staged). A skate flap was designed according to the authors' preferred technique and performed without any complications (Cases 21.1.1 & 21.1.2). In this case, two pieces of derma-fat grafts were used to enhance initial projection and long-term result

(Case 21.1.3). Her postoperative course was uneventful. The patient is quite happy with the overall appearance of her reconstructed nipples (Case 21.1.4). At 11-month follow-up, good size, shape and projection of the reconstructed nipple are well maintained (Case 21.1.5).

CASE 21.1—cont'd



• Case 21.1.1



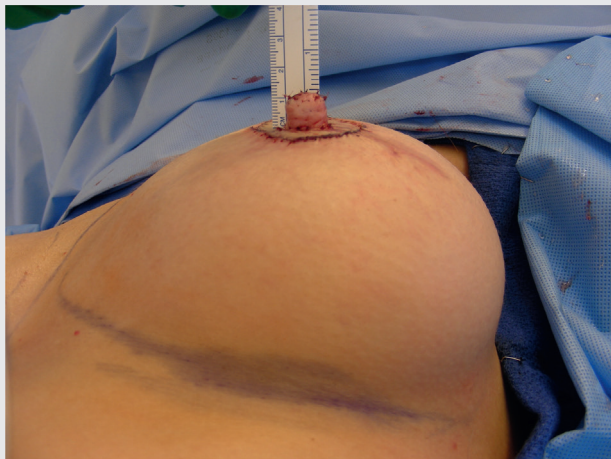
• Case 21.1.4



• Case 21.1.2



• Case 21.1.5



• Case 21.1.3

CASE 21.2

A 45-year-old white patient had successful bilateral breast reconstructions with silicone implant (immediate, two-staged). A skate flap was designed after the new nipple position was determined (Case 21.2.1). The NAC reconstruction was performed without any complications. In this case, two pieces of derma-fat grafts were inserted to the reconstructed nipple to add more initial projection and possibly improve long-term result (Case 21.2.2). Her postoperative course was uneventful. The patient is quite happy with the overall appearance of her reconstructed nipples (Cases 21.2.3 & 21.2.4). Even at 3-year follow-up, good size, shape and projection of the reconstructed nipple are reasonably well maintained (Case 21.2.5).



• Case 21.2.1



• Case 21.2.2



• Case 21.2.3



• Case 21.2.4



• Case 21.2.5

CASE 21.3

A 49-year-old African-American patient had a successful delayed left breast reconstruction with a free TRAM flap from her abdomens. A skate flap was designed after the new nipple position was determined ([Case 21.3.1](#)). The NAC reconstruction was performed without any complications. In this case, no derma-fat grafts were used ([Case 21.3.2](#)). Her

postoperative course was uneventful and her NAC reconstruction site completely healed within 2 weeks. The patient is quite happy with the overall appearance of her reconstructed nipple ([Case 21.3.3](#)). At 1-year follow-up, good size, shape and projection of the reconstructed nipple are well maintained ([Case 21.3.4](#)).



• Case 21.3.1



• Case 21.3.2



• Case 21.3.3



• Case 21.3.4

CASE 21.4

A 52-year-old African-American patient had a successful immediate right breast subpectoral/ADM tissue expander–based breast reconstruction. Patient underwent right nipple reconstruction with C-V flap and autologous dermal graft (Case

21.4.1). The postoperative course was uneventful (Case 21.4.2 shows the immediate result and Case 21.4.3 shows the result one week postoperatively). The patient was happy with the results 9 months after the operation (Case 21.4.4).



• Case 21.4.1



• Case 21.4.3



• Case 21.4.2



• Case 21.4.4

CASE 21.5

A 42-year-old white patient had successful immediate-delayed left breast reconstruction with free DIEP flap (Case 21.5.1). She underwent left breast nipple reconstruction using C-V flap. Her postoperative course was uneventful. Two years

postoperatively (Case 21.5.2), the patient is happy with the results and decided not to have tattooing for areola due to light contralateral areolar color.

CASE 21.5—cont'd

• Case 21.5.1



• Case 21.5.2

Advantages and Disadvantages of Each Reconstructive Option

In general, the skate flap will provide the patient with a better-maintained projection as well as a more artistically created areolar circle. However, it takes a longer time to perform this type of reconstruction and unfortunately there is a full-thickness skin graft donor site which also requires more time for wound healing. Fortunately, most women will have excess skin or a scar or dog-ear located somewhere on their body and to harvest a full-thickness skin graft is usually not a problem and can be justified.

For the C-V flap, although there is no skin graft required for such a reconstruction, the projection of the nipple is less well-maintained with time. This can be problematic when dealing with nipple reconstruction based on an implant-based reconstructed breast. Some authors advocate adding a derma-fat graft or even AlloDerm graft to improve the long-term result after the C-V flap reconstruction.^{5,6} In addition, nipple tattooing is required in order to form a darker area to represent the areolar circle. However, each surgeon, based on experience, can select either type of nipple reconstruction to achieve a good result, as demonstrated in this chapter.

Management of Complications

In general, the nipple reconstruction from the skate flap can heal quite well without a problem but the areolar circle reconstructed with a full-thickness skin graft may present with some minor wound-healing issues. Occasionally, the patient would have an area with delayed healing of the skin graft site. However, those minor problems can be treated primarily with longer dressing changes and no additional skin grafting is even needed in the authors' practice.

Similarly, C-V flaps tend to heal well. Risk of nipple necrosis/partial necrosis can be reduced by having the flap pedicle opposite of the mastectomy scar to maximize perfusion pressure. Nipple atrophy following the operation can be significant, sometimes requiring revision using a derma-fat graft for augmentation.

Secondary Procedures

Based on the authors' experience for the skate flap described in this chapter, occasionally there is excess skin once the skate flap has completely healed (Fig. 21.5A). This may be because less flap skin is removed during the initial nipple reconstruction with the skate flap. However, this kind of problem can be revised by de-epithelialization of a small portion of the excess skin and re-approximating the de-epithelialized skin in an office setting (Fig. 21.5B,C). Once the reconstructed nipple has healed after revision, its size and projection can be maintained in the long term and the outcome can be predicted (Fig. 21.5D).

Conclusion

The plastic surgeon should select his or her preferred technique, i.e. the skate flap or the C-V flap, for NAC reconstruction. Each technique can be mastered to achieve an optimal result for either flap or implant-based breast reconstruction with a relatively short learning curve. Both techniques are safe and effective with very minimal complications. However, long-term outcome after any type of NAC reconstruction can be less optimal especially after an implant-based breast reconstruction. Thus, effective communication with patients can be key for an overall satisfactory outcome.



• **Fig. 21.5** (A) Excess skin in the dorsal aspect of the reconstructed nipple 7 months after the skate flap reconstruction. (B) Excess skin in the dorsal aspect of the reconstructed nipple is marked and will be de-epithelialized. (C) Intraoperative view showing completion of the revision after the skate flap nipple reconstruction. (D) Results at 4 years after the revision. The size and projection of the reconstructed nipple after the skate flap reconstruction are well maintained.

PEARLS FOR SUCCESS

- Adequate soft tissue for nipple reconstruction over the reconstructed breast should be determined by a pinch test.
- The design of the reconstructed nipple should be based on adequate soft tissue over the reconstructed breast.
- The new nipple position can be adjusted based on the scar location over the reconstructed breast.
- In general, relatively low placement of the reconstructed nipple is preferred.
- Patient input regarding nipple position can be important and should be considered.
- Save as much skin flap tissue as possible to improve the result of nipple reconstruction.
- Add derma-fat graft if needed to improve long-term projection of a reconstructed nipple.
- Nipple reconstruction in a radiation field is possible, but should be approached with extreme care and preferably after fat grafting to the area.
- Minor revision of the reconstructed nipple may be needed for an optimal result.

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22

Nipple-Sparing Mastectomy

JORDAN D. FREY, ARA A. SALIBIAN AND NOLAN S. KARP

Introduction

Nipple-sparing mastectomy (NSM) is the most recent advancement in the surgical management of breast cancer, allowing for complete preservation of the nipple–areola complex along with the breast skin envelope.¹ Initially, NSM was largely limited to utilization in prophylactic cases. As experience with this technique has grown, oncologic safety has been demonstrated as comparable to skin-sparing and total mastectomy.^{2,3} As such, indications for NSM have expanded to therapeutic cases, including those with more advanced breast disease.^{4,5} Options for breast reconstruction after NSM include the full range of alloplastic and autologous techniques.¹ Importantly, NSM has been shown to significantly improve post-reconstruction patient-reported satisfaction and quality of life compared to non-NSM techniques.⁶

Reconstructive outcomes with NSM continue to be defined. Numerous patient-, operative-, and technique-specific factors have been demonstrated to variably influence outcomes.^{1,7–9} Overall, reconstructive safety has been demonstrated in implant-based and autologous breast reconstruction after NSM with rates of complications generally less than 7%.¹ Nipple-sparing mastectomy does place greater stress on the overlying skin envelope and requires careful preoperative planning as well as meticulous intraoperative technique to ensure successful breast reconstruction.^{1,10}

Indications and Contraindications

Appropriately selecting candidates is perhaps that most important component of successful breast reconstruction after NSM. Primarily, oncologic considerations prevail. While traditional oncologic contraindications for nipple-sparing mastectomy included large tumors and tumors within 1–2 cm of the nipple–areola complex, recent studies have demonstrated oncologic safety in patients with tumors within 1 cm of the nipple–areola complex.¹¹ Nipple–areola complex tumor involvement has been proposed as the most important oncologic consideration in patient selection for nipple-sparing mastectomy and remains the only absolute

oncologic contraindication at our institution.¹¹ Therefore, all patients undergoing mastectomy for prophylactic indications or for therapeutic indications without clinical nipple–areola complex disease involvement are offered NSM, so long as concurrent reconstructive considerations are met.

Multiple patient and operative risk factors have been variably identified in the literature as increasing risk of reconstructive complications. These include older age, elevated body mass index and mastectomy weight, preoperative radiation and chemotherapy, various mastectomy incisions, and smoking, among others.^{1,7} Data remains conflicting regarding the hazard posed by each individual risk factor. While no single such factor represents an absolute contraindication to NSM, candidates possessing multiple risk factors should be approached cautiously, counseled regarding their increased potential for complications, and may preferentially be offered skin-sparing or total mastectomy.

In our practice, patients with nipple to sternal notch distances of greater than 25 cm and/or severe grade II or grade III breast ptosis are at higher risk of reconstructive complications and poor aesthetic outcome, representing relative contraindications for NSM. However, patients with macromastia or breast ptosis may undergo NSM in a delayed fashion after staged reduction mammoplasty to reduce the breast envelope and optimize nipple–areola complex position. This is more appropriate in prophylactic cases such that sufficient time, typically three months, may elapse between the reduction mammoplasty and NSM. Lastly, patients with severe chest wall asymmetry or nipple–areola complex asymmetry are at higher risk of postoperative asymmetry and may be best served with skin-sparing techniques. Therefore, the optimal patients for NSM are women with small to moderate-sized breasts with minimal ptosis undergoing mastectomy for prophylactic or therapeutic indications without evidence of nipple–areola complex tumor involvement (Table 22.1).

Once a patient is established as a candidate for NSM, options for reconstruction must be determined, all of which are available after NSM. Within implant-based reconstruction methods, tissue-expander reconstruction is preferred for those desiring a larger postoperative breast size or patients with asymmetric nipple–areola complexes. Immediate,

TABLE 22.1 General Indications and Contraindications for Nipple-Sparing Mastectomy

Indications	Absolute Contraindications
Small-breasted patients Minimal ptosis (grade I to mild grade II) Nipple to sternal notch distance <25 cm	Clinical nipple–areola complex tumor involvement
Relative Indications	Relative Contraindications
Prophylactic mastectomy indication	Oncologic Large tumors Tumor-to-nipple distance <1 cm Reconstructive Macromastia Nipple to sternal notch distance >25 cm Breast ptosis (severe grade II to grade III) Older patient age Elevated body mass index Higher mastectomy weight Prior chemoradiation Active smoking status Severe chest wall, breast footprint, or nipple–areola complex asymmetry

direct-to-implant reconstruction is reserved for patients with good preoperative nipple–areola complex position who desire a similar postoperative breast size. Placement of immediate, permanent implants greater than 400 mL in volume has been shown to increase the risk of complications in NSM. Therefore, patients in whom predicted permanent implant size is greater than this threshold are best served with tissue expander–based reconstructions.¹² The full range of autologous reconstruction options are also available after NSM.¹

Preoperative Evaluation

Women presenting in consultation for NSM with immediate breast reconstruction should undergo a comprehensive assessment to determine their candidacy, primarily involving a complete breast examination. Further, a complete history must be ascertained including a determination of past medical and surgical history, body mass index, and smoking status, among other considerations. Specifically related to smoking status, pack-year and time-to-quitting smoking should be determined as patients undergoing NSM with a less than 10 pack-year history and greater than five years-to-quitting smoking have demonstrated equivalent outcomes to non-smokers.⁹

First, bilateral breasts are examined for any obvious or palpable lesions. While palpable or large tumors are not necessarily contraindications for NSM, their presence and location should be noted as they may influence incision choice and/or indicate the potential need for neoadjuvant or adjuvant chemoradiation. Next, the nipple–areola complexes are evaluated for any sign of clinical tumor involvement including palpable subareolar tumors, nipple discharge, and/or peau d'orange. Any evidence of such involvement would

represent an absolute contraindication for NSM due to risk of postoperative locoregional disease recurrence of nipple–areola complex origin. Any significant findings related to breast pathology should be discussed with and confirmed by the patient's surgical oncologist, as both parties must agree that the patient is an oncologic candidate for NSM prior to proceeding.

Once the patient is established as a candidate for NSM from an oncologic standpoint, reconstructive considerations must be evaluated. The overall chest wall and breast footprint(s) are generally examined. While mild to moderate nipple asymmetry may be remedied intraoperatively or in secondary revisions in NSM, severe nipple–areola complex asymmetry is difficult to correct and is a relative contraindication to NSM.¹³ The breast is also examined for prior surgical scars that may be incorporated into the ultimate incision utilized for NSM. Periareolar scars should be carefully examined as more recent incisions may compromise blood supply while older scars may serve as a delay to the nipple–areola complex, improving perfusion.

Breast size and ptosis are next evaluated. Standard breast measurements, including nipple to sternal notch distance, nipple to inframammary fold distance, and base width should be measured. Patients with small to moderate-sized breasts and grade I to mild grade II ptosis (sternal notch to nipple distance less than or equal to 25 cm) represent the best candidates for NSM. Macromastia patients or those with severe grade II to grade III ptosis (sternal notch to nipple distance greater than 25 cm) should be approached cautiously. These patients are at greater risk of poor perfusion, ischemic complications, postoperative nipple malposition, and poor aesthetic result.¹³ Therefore, patients with larger or more ptotic breasts are best served with skin-sparing techniques or undergoing delayed NSM after staged

reduction mammoplasty. Immediate breast reconstruction in NSM using a skin reduction pattern incision is possible but is prone to high rates of wound healing complications.

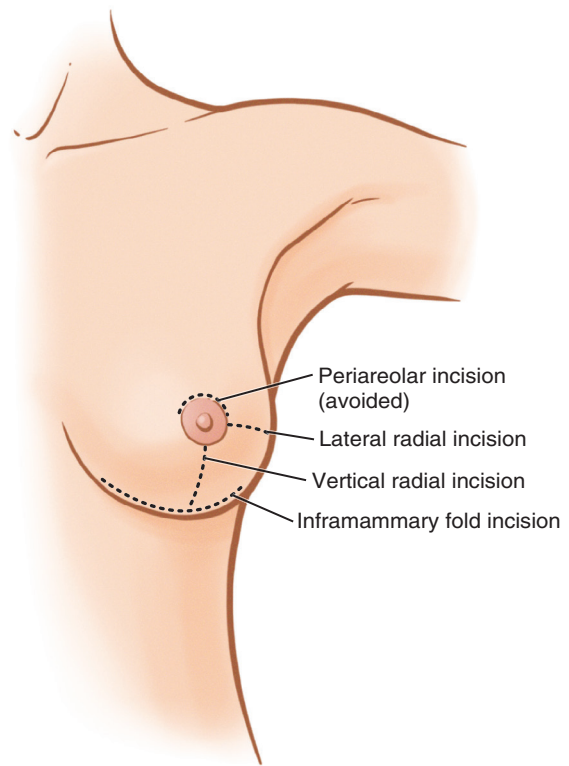
The quality and laxity of the breast envelope is also assessed. Good breast skin quality and minimal laxity, represented by a pinch test of greater than 2 cm and snap-back in each breast quadrant, are optimal for NSM. In these patients, the breast-skin envelope can accommodate well to the underlying reconstruction, whether alloplastic or autologous.

Once a patient has been determined to be a candidate for NSM from both an oncologic and reconstructive perspective, options for reconstruction should be discussed with the patient. While no algorithm exists to predict individualized risk of complications in NSM, a discussion should also take place regarding present risk factors and their potential influence on the perioperative risk profile of each individual patient. Patients must be counseled on the possibility of adjustments to the operative plan based on intraoperative findings that may require removal of the nipple–areola complex or conversion from a one-stage to a two-stage alloplastic reconstruction. Factors requiring such adjustments may include positive findings of subareolar biopsy or evidence of poor perfusion upon assessment of the mastectomy flaps intraoperatively. If the intraoperative nipple biopsy is positive for cancer or the nipple is found to be ischemic and requires excision, a plan on how to handle the contralateral nipple needs to be discussed.

Surgical Techniques

Prior to entering the operating room, the patient's midline is marked along with the inframammary fold, superior breast border, and planned mastectomy incision. The choice of mastectomy incision is made in concert with the breast surgeon. Lateral radial incisions offer good surgical access for NSM and subsequent reconstruction, making them a good choice for routine NSM in breast cancer patients with implant-based reconstruction. These incisions also can offer access to the axilla for lymph node biopsies. An effort is made in cases of prophylactic NSMs to utilize inframammary fold incisions as they offer the advantage of minimizing the visible postoperative scar burden. Surgical access for mastectomy with inframammary fold incisions is more challenging and is best utilized in patients with small to moderate-sized breasts. Lastly, vertical incisions are utilized preferentially for microsurgical autologous NSM reconstruction as they afford greater access to the internal mammary vessels. Periareolar incisions have been associated with increased complications in NSM and are very infrequently utilized in our practice (Fig. 22.1).

Upon entering the operating room, the patient lies supine on the operating room table with the arms abducted 90 degrees. The breast is infiltrated with a dilute solution of lidocaine and epinephrine. This assists in hydrodissection of the proper mastectomy plane, facilitates a bloodless field, and also improves postoperative pain control and minimizes

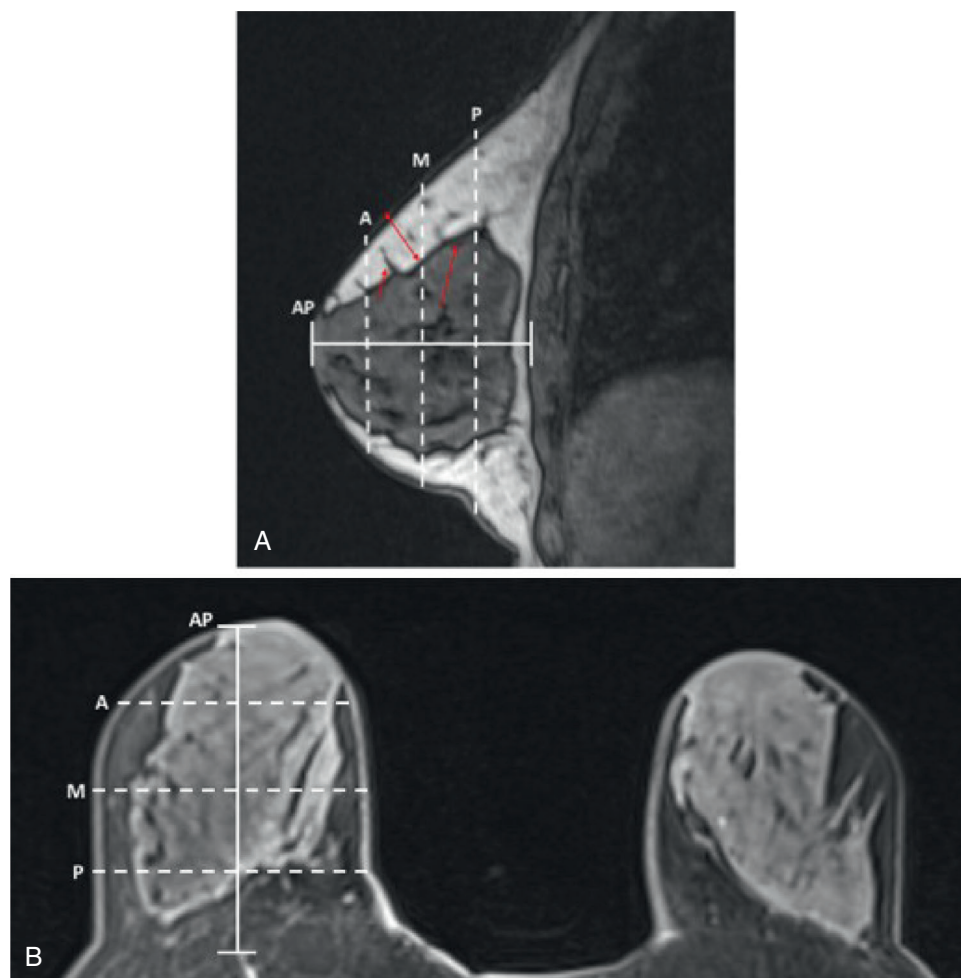


•**Fig. 22.1** Various mastectomy incisions are available for nipple-sparing mastectomy with various associated advantages and disadvantages.

postoperative nausea and vomiting. One limitation of using this solution is that intraoperative angiography may not be reliably utilized if there is a question of skin flap viability, necessitating reliance on clinical judgment.

Next, NSM proceeds through the chosen mastectomy incision. Great care is taken to perform the mastectomy in the appropriate plane, being at the level of the superficial breast fascia (Video 22.1). This is an anatomic plane that is present, but variably defined, in all individual patients using magnetic resonance imaging¹⁰ (Fig. 22.2). It has been demonstrated that patients with thinner postoperative NSM flap thickness and a reduced post-/preoperative NSM flap thickness ratio have higher rates of reconstructive complications in NSM. This emphasizes the importance of precise dissection at this level to both maximize removal of breast tissue and perfusion of the breast envelope.

NSM is optimally performed using cold dissection with a blade or dissecting scissors with minimal electrocautery. Complete mastectomy using the standard anatomic borders is performed. Once the subareolar area is reached, a small biopsy is routinely taken to be sent for frozen and permanent pathologic examination. Positive results on frozen section mandate removal of the nipple–areola complex intraoperatively. Positive results on permanent pathologic examination after a negative result on frozen section requires delayed removal of the nipple–areola complex either under local anesthesia in the office or as a separate operative procedure. In our experience, 2.2% and 3.9% of frozen and permanent



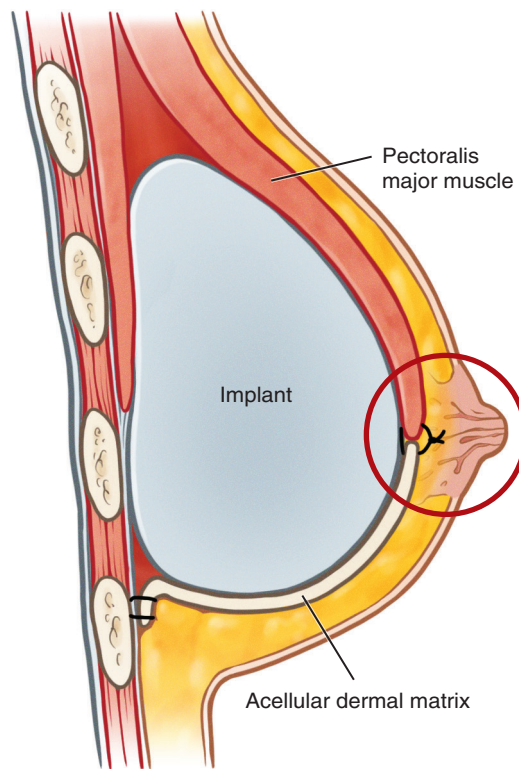
• **Fig. 22.2** Sagittal non-fat saturated MRI (A) and axial high-resolution post-contrast MRI (B) demonstrating the superficial breast fascia with underlying breast parenchyma and overlaying subcutaneous fat and skin. AP, anteroposterior distance of breast; A, anterior measurement at $\frac{1}{4}$ of AP distance; M, middle measurement at $\frac{1}{2}$ AP distance; P, posterior measurement and $\frac{3}{4}$ AP distance; short red arrow, Cooper's ligament with breast tissue extending to dermis; long red arrow, anterior mammary fascia; double-headed red arrow, example of flap thickness measurement at middle location.

subareolar biopsies were positive, yielding a sensitivity and specificity of frozen subareolar biopsy in NSM of 0.58 and 1.0, respectively.¹⁴ Any axillary procedures may be performed through the mastectomy incision or a separate incision in the axilla. Throughout the procedure, retraction of the skin flaps should be gentle using atraumatic retractors.

Once NSM is completed, the plastic surgeon must assess the status of the mastectomy flaps and nipple–areola complex. Exposed dermis and the absence of bleeding from wound edges are most suggestive of compromised vascularity. Absolute thickness of the subcutaneous layer varies by patient as dissection at the level of the superficial breast fascia appears to be the most important anatomic factor in skin flap perfusion. Intraoperative tissue angiography may supplement clinical judgment; however, injection of vasoactive solutions will render the angiography unreliable and is a trade-off for the advantage of a bloodless dissection. Compromised tissue, including the nipple–areola complex, should be excised as inevitable ischemia and wound

breakdown will only risk the ultimate reconstruction. Alternatively, the mastectomy flaps may be closed without reconstruction with a plan for secondary alloplastic or autologous reconstruction in three to four weeks in a delayed fashion. Once the breast skin flaps are judged to be viable, implant-based or autologous reconstruction proceeds.

In alloplastic reconstruction, our preference is to utilize total or partial submuscular device coverage for implant-based reconstruction with standard elevation of the pectoralis major muscle. Patients with very small breasts may be served with total submuscular coverage. However, the underlying implant pocket in NSM must be matched to the overlying skin envelope, which is completely or largely preserved compared to non-NSM techniques. Therefore, scaffold support to expand and cover the inferolateral aspect of the implant pocket is employed in the majority of cases. When scaffolds are utilized, the inferior pectoralis is released from its origins to the level of the medial attachments. The scaffold is secured to the inframammary fold



• **Fig. 22.3** Sagittal diagram of an immediate, permanent implant-based breast reconstruction after NSM with the nipple position secured with a suture from the undersurface of the nipple–areola complex to the underlying muscle and acellular dermal matrix scaffold.

inferiorly and the chest wall at the level of the anterior axillary line laterally. The device, whether a tissue expander or permanent implant, may then be placed and the scaffold is sutured to the edge of the pectoralis. In total sub-muscular coverage, the serratus fascia and/or muscle are elevated to the level of the anterior axillary line, after which the device is placed and the muscle/fascial edges are sutured together.

Autologous reconstruction after NSM proceeds as for non-NSM procedures. In these cases, great care must be taken to minimize prolonged retraction on the skin flaps, which can lead to increased skin tension and pressure,

causing ischemic complications. Multiple periods of relaxation of the skin flaps from retraction are recommended to avoid such sequela.

Regardless of reconstruction modality, measures should be taken to optimize nipple–areola complex position at the most projecting portion of the breast mound (Fig. 22.3). At the end of the reconstruction, the nipple–areola complex may be secured in the desired position either by suturing to the underlying muscle, scaffold, or autologous tissue or the position may be set manually with drains subsequently placed to closed suction, providing negative pressure to maintain nipple–areola complex position.¹³

Case Examples

CASE 22.1

This is a 55-year-old patient with left-sided breast cancer who presented for evaluation for bilateral mastectomy with subsequent breast reconstruction. She has small breasts with bilateral grade I ptosis with mild glandular ptosis. She desired a final postoperative breast size that was larger than her preoperative size (Case 22.1.1).

The patient underwent bilateral nipple-sparing mastectomy through inframammary fold incisions with tissue

expander-based reconstruction in a partial submuscular pocket with human acellular dermal matrix support. She ultimately underwent tissue expander exchange for 550-mL smooth, round high-profile permanent implants. The patient healed well with no complications or issues and no additional reconstructive procedures.

Continued

CASE 22.1—cont'd

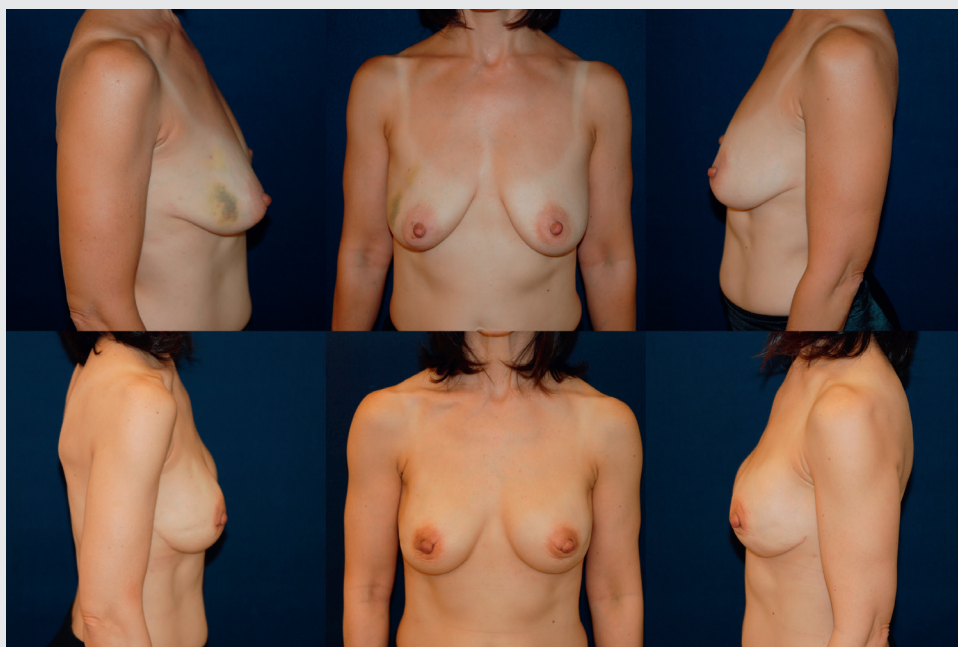
• Case 22.1.1

CASE 22.2

This is a 48-year-old patient with right breast cancer who presents in consultation for bilateral mastectomy and breast reconstruction. Her current breast size is large B cup to small C cup with minimal grade I ptosis. She desires to have a similar postoperative breast size ([Case 22.2.1](#)).

She underwent bilateral nipple-sparing mastectomy utilizing inframammary fold incisions. Given her desire for similar

postoperative breast size, excellent skin envelope, and minimal ptosis, breast reconstruction proceeded with immediate insertion of 234-mL moderate profile smooth, round permanent implants. The implants were placed in a partial submuscular pocket with human acellular dermal matrix for inferolateral support and coverage. The patient healed well with no complications or additional reconstructive procedures.

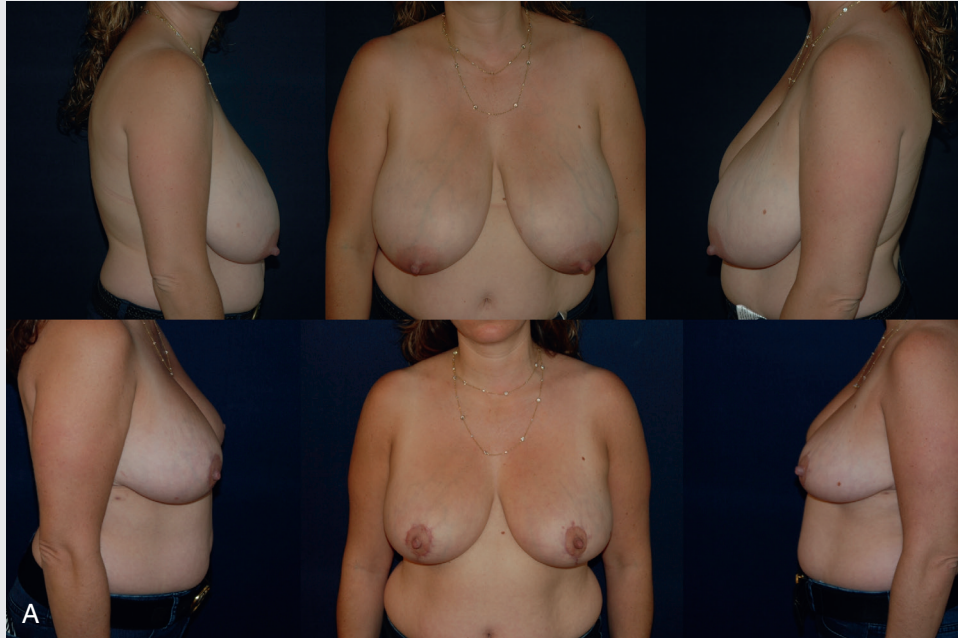


• Case 22.2.1

CASE 22.3

This is a 38-year-old patient who originally presented for bilateral breast reduction (Case 22.3.1A). She underwent bilateral reduction mammoplasty and was incidentally found to have invasive lobular carcinoma in the right breast on pathologic examination. Three-months postoperatively from this procedure, she underwent bilateral nipple-sparing mastectomy utilizing the vertical and lateral limbs of the prior Wise pattern incisions for surgical access. She then underwent

immediate single-stage direct-to-implant reconstruction with 550-mL high-profile smooth, round permanent implants (Case 22.3.1B). She experienced no complications and underwent no further reconstructive procedures. Case 22.3.1C shows her appearance prior to reduction mammoplasty (top row) and after nipple-sparing mastectomy and direct-to-implant reconstruction (bottom row).



• Case 22.3.1A



• Case 22.3.1B

Continued

CASE 22.3—cont'd



• Case 22.3.1C

Postoperative Care and Expected Outcomes

Incisions and drain sites are generally dressed with wound closure strips and non-adhesive gauze with an overlying occlusive dressing. The nipple–areola complex is dressed with antibiotic ointment, non-adhesive gauze, and an occlusive dressing. While in the hospital, patients receive analgesics as needed along with intravenous antibiotics covering skin flora.

Patients undergoing alloplastic reconstruction generally are discharged on the first or second postoperative day. Autologous reconstruction patients generally are discharged on the third or fourth postoperative day. Patients are discharged with oral pain medication and antibiotics for one week given the increased tissue stress and inherent infection risk with nipple-sparing mastectomy.

Dressings are maintained for one week and removed at the first postoperative clinic visit. At this time, patients wear a soft brassiere with no underwire and padding surrounding the incision and nipple–areola complex for four weeks. Drains are maintained until their output is less than thirty mL for two consecutive days. Patients may sponge bathe around the surgical sites until dressings and drains are removed. Patients are frequently evaluated in the clinic postoperatively to expeditiously identify and manage any wound healing issues, both involving the nipple–areola complex and otherwise.

Management of Complications

In appropriately selected patients, complications after nipple-sparing mastectomy generally range from 1% to 13%.¹ The most common complications include nipple–areola complex and mastectomy flap necrosis as well as infection. Ischemic complications after NSM should be carefully monitored for and accurately diagnosed in the outpatient setting. Partial-thickness, or minor, nipple–areola complex and mastectomy flap necrosis, with an incidence ranging from 5% to 13%, are managed with local wound care.¹ Full-thickness nipple–areola complex and mastectomy flap necrosis, ranging from 1% to 7%, should be managed aggressively with excision and closure either in the office or operating room.¹ Autologous, compared to alloplastic, reconstructions permit greater flexibility for management of full-thickness nipple–areola complex or mastectomy flap necrosis in NSM.

Infection after NSM ranges from 1% to 7%, dependent on the type of reconstruction employed.¹ Minor, localized infection can be managed with oral antibiotics in the outpatient setting. More severe infections or those resistant to an oral regimen are managed with inpatient hospital admission and intravenous antibiotics. Continually persistent infections warrant imaging to assess for any collections requiring drainage. Similar to ischemic complications, infectious sequela after NSM carry variable consequences based on

TABLE 22.2 Comparative Outcomes of Patient Undergoing Nipple-Sparing Mastectomy and Undergoing Alloplastic and Autologous Breast Reconstruction at NYU Langone Health

	Tissue Expander–Based Reconstruction	Immediate, Permanent Implant–Based Reconstruction	Autologous–Based Reconstruction
Reconstructive Complications	Partial nipple necrosis: 5.8% Complete nipple necrosis: 1.3% Major infection: 1.1% Minor infection: 7.1% Major mastectomy Flap necrosis: 1.9% Minor mastectomy Flap necrosis: 7.7% Explantation: 2.3% Implant failure: 2.4% Seroma: 1.1% Hematoma: 1.9%	Partial nipple Necrosis: 7.8% Complete nipple necrosis: 3.9% Major infection: 1.7% Minor infection: 3.0% Major mastectomy Flap necrosis: 6.5% Minor mastectomy Flap necrosis: 12.9% Explantation: 3.4% Implant failure: 3.9% Seroma: 0.4% Hematoma: 1.7%	Partial nipple Necrosis: 4.9% Complete nipple necrosis: 3.0% Major infection: 0.8% Minor infection: 1.1% Major mastectomy Flap necrosis: 5.3% Minor mastectomy Flap necrosis: 9.1% Flap failure: 1.1% Partial flap necrosis: 0.8% Flap revision: 3.0% Seroma: 0.4% Hematoma: 2.3% Breast abscess: 0.4%

(Adapted from: Frey JD, Choi M, Salibian AA, Karp NS. Comparison of outcomes with tissue expander, immediate implant, and autologous breast reconstruction in greater than 1000 nipple-sparing mastectomies. *Plast Reconstr Surg*. 2017;139(6):1300–1310.)

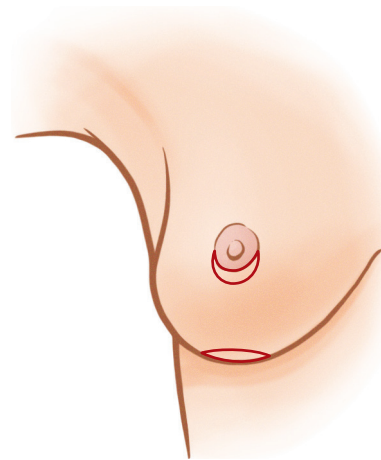
severity as well as reconstructive modality. Implant-based reconstructions complicated by severe infections may mandate device exchange or removal after debridement and washout.

Reconstructive failure after NSM is uncommon. With alloplastic reconstruction, rates of device failure are 2.4% and 3.9% for tissue expander and direct-to-implant reconstructions, respectively.¹ Rates of flap failure after NSM are generally near 1%.¹ Less common complications after NSM include seroma and hematoma, within the range of 1% to 2%.¹ Overall, NSM has been shown to be safe in the setting of all alloplastic and autologous reconstruction techniques. However, outcomes after NSM are dependent on the reconstruction modality employed. Tissue expander–based reconstructions generally have the lowest rate of complications compared to one-stage alloplastic or autologous techniques, but notably have higher rates of minor infection (Table 22.2).

Importantly, locoregional recurrence after NSM is comparable to traditional mastectomy techniques with a rate of 0.5% found at our institution with a follow-up of approximately four years. Any concern for locoregional recurrence should prompt imaging and tissue biopsy. Biopsy-proven locoregional recurrence will require excision and adjuvant therapies as determined by the patient's oncologic treatment team.

Secondary Procedures

Specifically related to NSM, patients may require secondary adjustment of the nipple–areola complex position on the breast mound. Otherwise, secondary procedures after NSM mirror those required in breast reconstruction after non-NSM. In our experience, the rate of correction of nipple–areola complex malposition is approximately 7.4%.¹³



• **Fig. 22.4** Skin markings for periareolar crescentic excision (above) and directional skin excision (below) to reposition the nipple–areola complex more inferiorly in a case of superior nipple–areola complex superior malposition.

The most common techniques utilized were crescentic periareolar excision (32.5%), capsule modification (18.2%) and directional skin excision (13.0%). In cases of malposition in alloplastic NSM reconstruction, the source of malposition must be identified as due to skin issues or a capsular issue, such as capsular contracture. Crescentic periareolar and directional skin excisions are performed in cases in which the nipple–areola complex requires mild to moderate repositioning due to a skin issue. Mastopexy-type procedures may be utilized for more severe nipple–areola complex malposition due to a skin issue in which greater repositioning is required. Capsule modification, including capsulotomy, capsulectomy, and capsulorrhaphy are utilized in cases of malposition due to capsule issues¹³ (Fig. 22.4).

Secondary nipple repositioning after NSM may be safely performed in cases of both alloplastic and autologous reconstruction. In implant-based NSM reconstruction, nipple–areola complex repositioning must take place with care to avoid injuring the underlying implant. Further, the nipple–areola complex is nourished only via the subdermal plexus of the prior mastectomy flaps, increasing the risk of ischemic nipple–areola complex compromise and subsequently limiting the ability to re-develop mastectomy flap planes in mastopexy-like procedures. Therefore, skin procedures involving only de-epithelialization rather than full-thickness excision, or capsule-based procedures are more prudent to employ. Conversely, in autologous NSM reconstruction, the nipple–areola complex derives its blood supply via the mastectomy flap subdermal plexus as well as from the underlying vascularized tissue. More aggressive nipple–areola complex repositioning maneuvers, such as Wise pattern mastopexy techniques, can thus be employed.¹³

Independent risk factors for nipple–areola complex malposition requiring secondary repositioning after NSM include prior radiation, vertical radial mastectomy incisions, and autologous reconstruction.¹³ Preoperative chest wall, breast footprint, or nipple–areola complex malposition will also predispose patients to greater risk of postoperative malposition.

After NSM, certain patients may desire reduction or augmentation of nipple projection. Nipple reduction may be performed with a simple excision. Nipple augmentation may be accomplished using fat or dermal grafts. In cases of complete, full-thickness nipple necrosis, secondary nipple reconstruction will be indicated after full wound healing. Standard techniques, including C-V and skate flaps, may be utilized.

Various other secondary procedures, such as fat grafting, may be desired and indicated in patients undergoing breast reconstruction after NSM, similar to non-NSM techniques. In cases of unilateral NSM, contralateral symmetrizing procedures may be desired and indicated including both reduction/mastopexy and augmentation techniques. While contralateral symmetrizing procedures may be performed at the time of immediate NSM reconstruction, they may be executed more precisely in a secondary manner.

Conclusions

Nipple-sparing mastectomy allows for complete conservation of the nipple–areola complex as well as majority of the breast-skin envelope. NSM has been associated with improved aesthetic outcomes and patient satisfaction compared to traditional mastectomy techniques. Importantly, oncologic outcomes with NSM appear similar to those with non-NSM techniques. Meanwhile, various factors have been associated with increased reconstructive complications after NSM, emphasizing the importance of careful preoperative patient evaluation and selection as well as intraoperative technique.

PEARLS FOR SUCCESS

- Nipple-sparing mastectomy permits complete preservation of the nipple–areola complex while offering the full range of alloplastic and autologous reconstruction techniques.
- Clinical evidence of nipple–areola complex tumor involvement represents the only current absolute contraindication to nipple-sparing mastectomy.
- Reconstructive considerations include various patient-, breast-, and operative-specific factors that alone carry variable risk, but in combination represent relative contraindications to nipple-sparing mastectomy.
- Nipple-sparing mastectomy is best performed after preoperative infiltration of a dilute solution of lidocaine and epinephrine with minimal intraoperative use of electrocautery and care taken to perform the dissection anatomically at the level of the superficial breast fascia.
- Frozen and permanent subareolar biopsies may routinely be performed, with frozen biopsies demonstrating high specificity for occult breast disease.
- Prior to proceeding with reconstruction, the mastectomy flaps, particularly the nipple–areola complex, should be carefully assessed to ensure adequate perfusion.
- In appropriately selected patients, rates of reconstructive complications after nipple-sparing mastectomy generally range from 1% to 13% with the most common being nipple–areola complex and mastectomy flap necrosis as well as infection, while oncologic outcomes appear equivalent to traditional mastectomy techniques.

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23

Correction of Poland Syndrome Breast Deformity

EMMANUEL DELAY AND ANDREEA CARMEN MERUTA

Introduction

Poland syndrome is a complex malformation syndrome and was first described by Alfred Poland in 1841 and in French literature by Lallemand in 1826. The diagnosis is clinical and the malformations are not life-threatening. The impact is mostly psycho-social and the malformations become more visible at puberty when the growing process is accelerated. The functional impact is minimal, even in hypoplasia or agenesis of several muscles.¹

Clinically, Poland syndrome presents with hypotrophy or agenesis of one or more muscles of one side of the thoracic wall or thoracic cage and sometimes the ipsilateral hand. The constant malformation encountered is agenesis of the sterno-costal insertions of the pectoralis major muscle. It can also be associated with complete agenesis of the pectoralis major, pectoralis minor, breast tissue and sometimes of the latissimus dorsi muscle or other muscles of the rotator cuff. When involving the breast, the skin is very thin with small or no amount of subcutaneous tissue and mammary gland agenesis or hypotrophy. In more severe cases, Poland syndrome can be associated with osseous and cartilaginous deformities of the chest wall on the affected side and also hand malformations.

In this chapter, we focus on the treatment of breast deformities in Poland syndrome. These deformities have an important psycho-social impact on young females and this is why they consult at a young age for a solution to their breast asymmetry. The breast deformity can be augmented by an underlying thoracic deformity. For the treatment of this syndrome numerous corrective surgical techniques have been developed: from bone and cartilage correction in cases with severe deformities, to implants for the chest wall, or breast implants and tissue expanders, fat transfer and flaps. These techniques can be used individually or they can be associated for a better aesthetic result.

Indications and Contraindications

Depending on the severity of the breast malformations present in patients with Poland syndrome, the patients can

be classified into three major categories: mild, moderate and severe, according to the classification described by Foucras et al.² (Table 23.1).

For patients with mild breast deformity (Fig. 23.1), our preferred correction technique is fat transfer or lipomodeling. It can also be corrected using a combination of lipomodeling and mammary implants of asymmetric size, when the patient desires breast augmentation. This technique requires several operations to achieve the desired volume and symmetry.

For patients with moderate breast deformity (Fig. 23.2), our preferred approach has been latissimus dorsi transfer and breast implants or tissue expanders. In our team, we prefer to perform autologous reconstruction for these young patients and our preferred method is fat transfer. We use lipomodeling exclusively if the patient has enough fat deposits to allow four or five fat grafting sessions. If there are not enough fat deposits and we can perform only two lipomodeling sessions, we combine these with silicone implant reconstruction. The reconstruction can be obtained by combining lipomodeling with tissue expander and silicone breast implant. The purpose of lipomodeling in these cases is to increase tissue thickness for a better aesthetic result and better implant coverage.

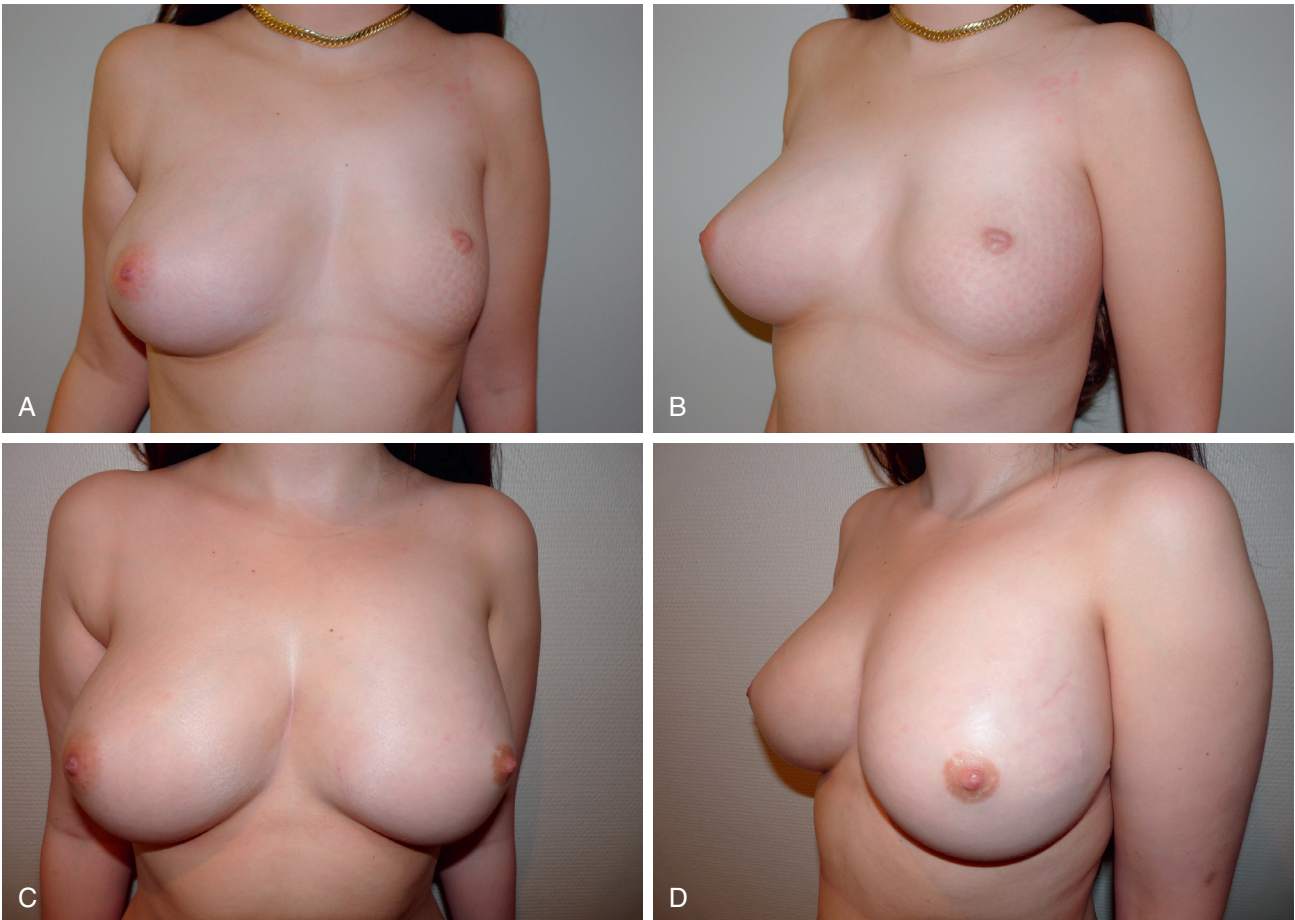
For patients with severe breast deformity (Fig. 23.3), if rib aplasia is present, rib reconstruction can be performed first, or personalized silicone implants created using a 3-D mould taken from the patient or a 3-D CT-scan reconstruction. The breast can be reconstructed using the previously described techniques. If the latissimus dorsi is hypoplastic as can sometimes be the case, other flaps can be used, such as the deep inferior epigastric perforator (DIEP) free flap and, if there is not enough abdominal laxity, superior gluteal artery perforator (SGAP) or inferior gluteal artery perforator (IGAP) flaps are good options.

Preoperative Evaluation and Special Considerations

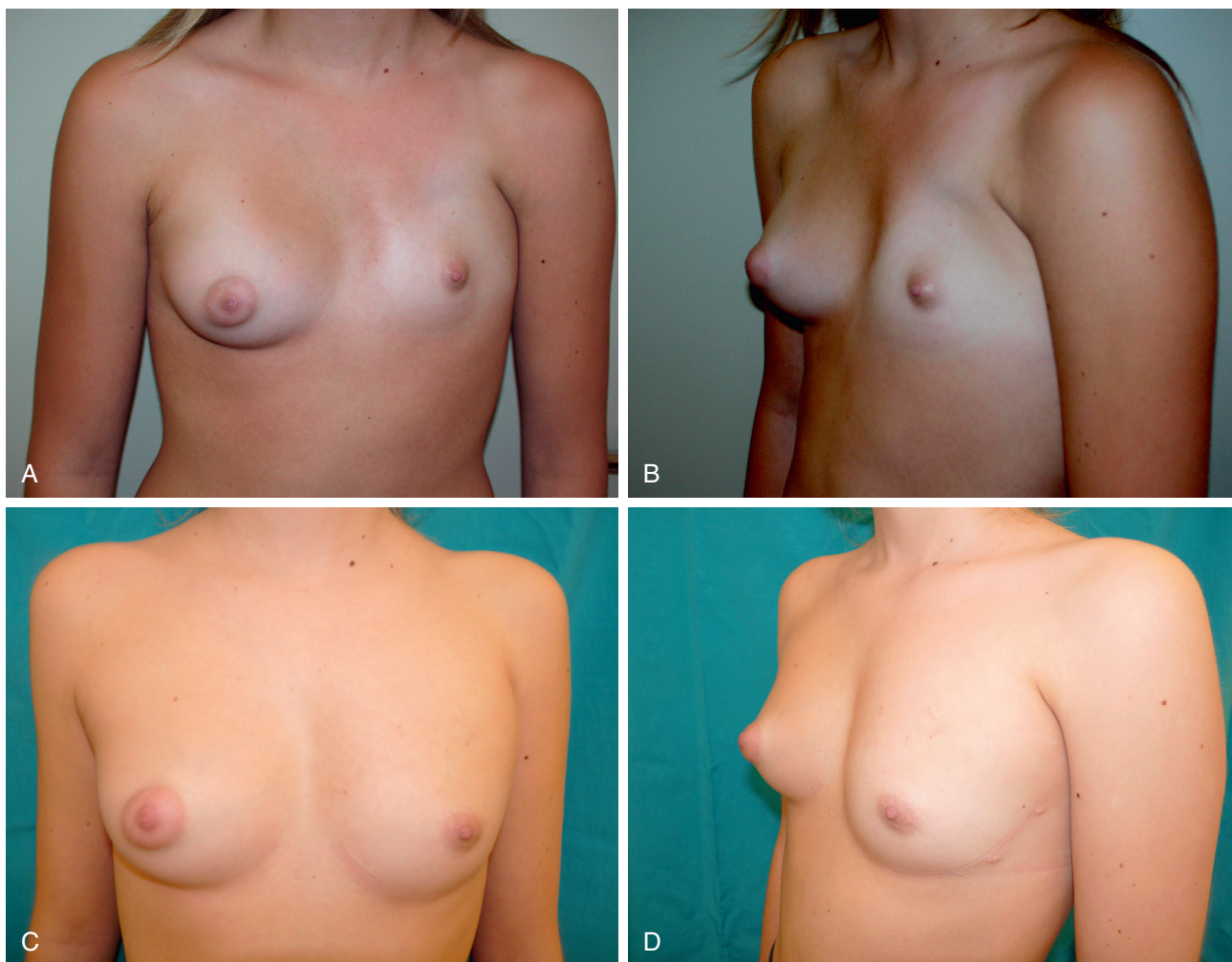
The diagnosis in Poland syndrome is mainly clinical. Examination of the pectoralis major muscle is done by adduction against resistance.

TABLE 23.1 Poland Syndrome Classification

Stage	Deformity	Clinical
Stage I (Fig. 23.1A,B)	Mild deformity	• Mammary gland hypoplasia • Nipple–areola complex hypoplasia • Pectoralis major hypoplasia
Stage II (Fig. 23.2A,B)	Moderate deformity	• Breast hypotrophy • Nipple–areola complex hypotrophy and displacement • Absence of the pectoralis major sterno–costal insertions • Absence of the anterior axillary fold • Volume deficiency in the cleavage area on the affected side
Stage III (Fig. 23.3A,B)	Severe deformity	• Breast agenesis • Sometimes nipple–areola complex agenesis • Absence of the pectoralis major muscle • Hypotrophy or agenesis of ribs and sternum • Very thin covering skin • Little or no subcutaneous fat • Absence of the anterior axillary fold • Hypotrophy or agenesis of one or several muscles of the rotator cuff



• **Fig. 23.1** Stage I or mild Poland syndrome breast deformity. A 21-year-old patient with Poland syndrome breast deformity. (A) Preoperative frontal view. (B) Preoperative $\frac{3}{4}$ lateral view. (C) Two years postoperative frontal view. (D) Two years postoperative $\frac{3}{4}$ lateral view.



• **Fig. 23.2** Stage II or moderate Poland syndrome breast deformity. A 15-year-old patient with Poland syndrome breast deformity. (A) Preoperative frontal view. (B) Preoperative $\frac{3}{4}$ lateral view. (C) One year postoperative frontal view. (D) One year postoperative $\frac{3}{4}$ lateral view.

The absence of the anterior axillary fold is a pathognomonic sign of pectoralis major agenesis. Thoracic wall deformities like pectus excavatum can also be observed if chondro-osseous deformities are present. The presence of latissimus dorsi muscle can be confirmed by adduction against resistance and by the existence of the posterior axillary fold.

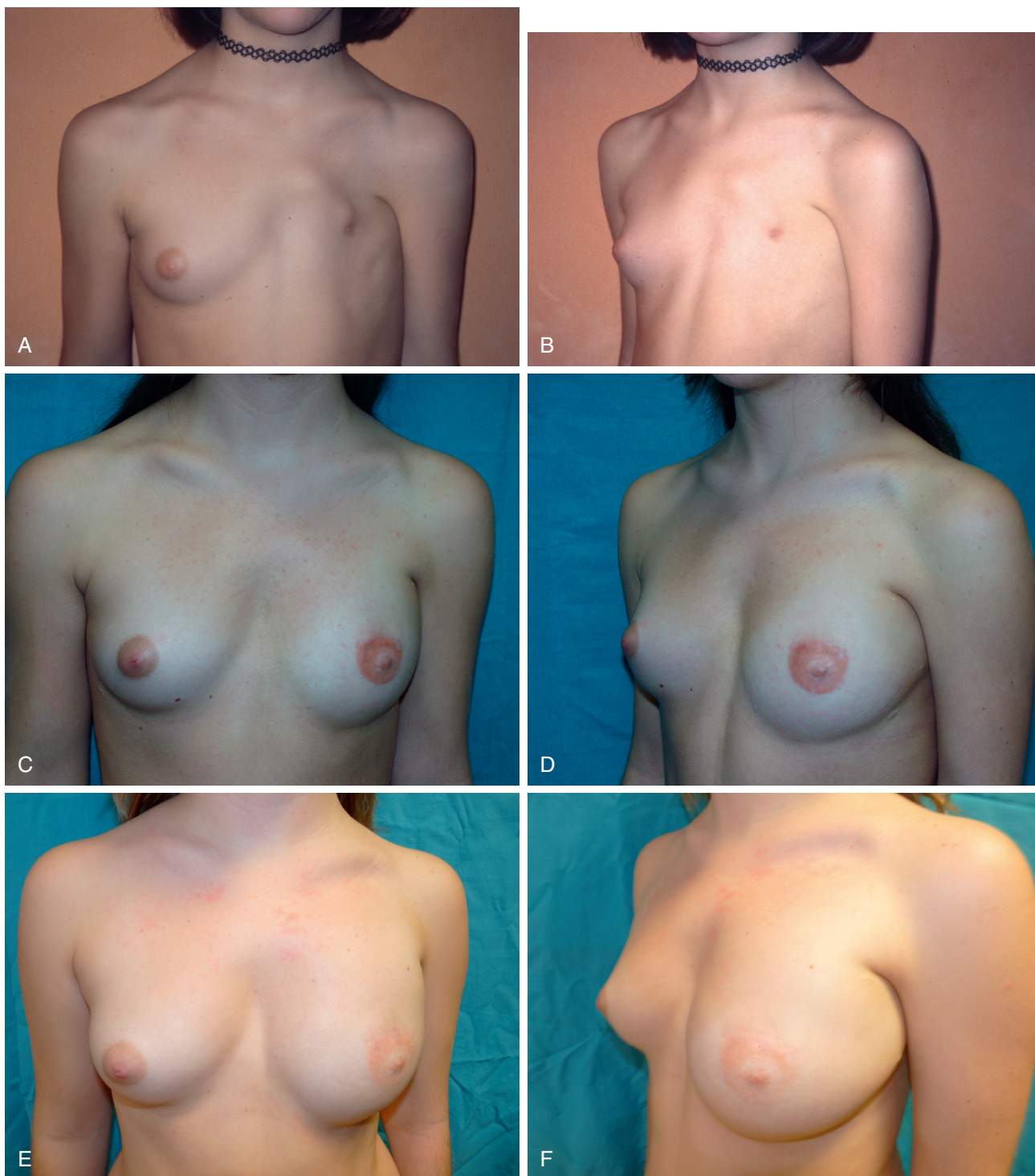
Breast examination is also mainly clinical: the presence or absence of mammary tissue, the position of the nipple–areola complex, the presence or absence of the nipple–areola complex, and the skin and subcutaneous tissue thickness should be noted. It is also essential to analyze the contralateral breast: dimensions, base width, ptosis, hypertrophy.

The mild forms do not require any specific exams. A breast ultrasound can be performed before surgical treatment.

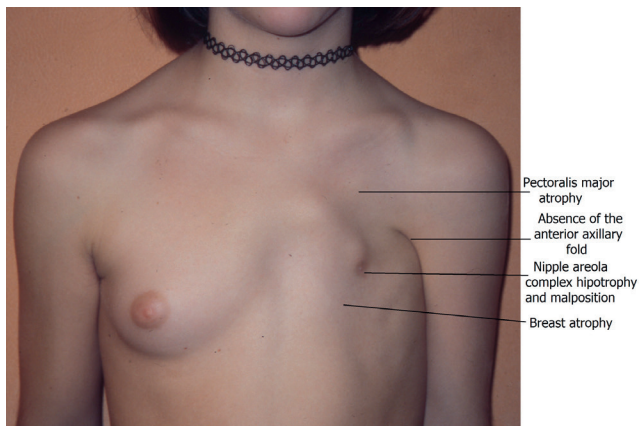
When treating severe deformities, a CT scan with 3-D reconstruction should be performed in order to have a complete analysis of all deformities and, if necessary, the scanner can be a useful tool in personalized chest wall silicone implant creation.

The algorithm that we use in our practice is:

- For mild cases (stage I):
 - fat grafting in several sessions (2–4 sessions) spaced by ~3 months (our first choice of treatment)
- For moderate cases (stage II):
 - fat grafting in several sessions (4 or more sessions)
 - lipomodeling in association with breast expanders and breast implants if the patient does not have enough fat deposits and she desires breast augmentation
 - short scar total autologous musculocutaneous latissimus dorsi flap in association with fat grafting
 - the pectoro-mammary flap in association with lipomodeling when the contralateral breast is hypertrophic and the patient desires autologous reconstruction without other donor sites, or when the latissimus dorsi is absent or hypotrophic
 - free flaps such as DIEP, SGAP, IGAP or transverse upper gracilis (TUG)
- For severe cases (stage III):
 - the thoracic wall can be corrected first if required with personalized silicone implants and afterwards the



• **Fig. 23.3** Stage III or severe Poland syndrome breast deformity. A 12-year-old patient with Poland syndrome breast deformity. (A) Preoperative frontal view. (B) Preoperative $\frac{3}{4}$ lateral view. (C) One year postoperative frontal view. (D) One year postoperative $\frac{3}{4}$ lateral view. (E) Eleven years postoperative frontal view. (F) Eleven years postoperative $\frac{3}{4}$ lateral view.



• **Fig. 23.4** Photo showing the main deformities in Poland syndrome: breast atrophy, nipple–areola complex hypotrophy and displacement, pectoralis major hypotrophy or atrophy and absence of the anterior axillary fold.

breast reconstruction is performed as shown for stage II deformities.

Surgical Techniques

Relevant Anatomy in the Poland Syndrome

The constant deformity is agenesis of the sternal insertions of the pectoralis major muscle. The most frequently described form of Poland syndrome is the association of breast and pectoralis major hypoplasia without upper limb malformations (Fig. 23.4).

In regard to the muscular malformations, most authors describe agenesis of the inferior and middle pectoralis major fascicles. The clavicular fascicle of the pectoralis major muscle is usually normal. Seyfer et al.³ found that in 20% of cases the clavicular fascicle is absent and these patients present clinically with an infraclavicular depression and the absence of the anterior axillary fold.

There are other muscles that can be hypoplastic or absent: pectoralis minor, serratus anterior, latissimus dorsi (in about 10% of cases), intercostal muscles, rectus abdominis muscle on the affected side, external oblique muscle, deltoid muscle, trapezius muscle, the supraspinatus and infraspinatus muscles.

The skin on the affected side is usually thin with little or no subcutaneous tissue. This deformity is more frequent in men. The absence of axillary hair and sudoriferous glands can also be recorded in some patients.

Sometimes a bridle is present at the level of the anterior axillary fold, and it limits the abduction movement of the arm. The mammary gland is usually hypotrophic and it can also be atrophic or absent. The breast hypoplasia can be accentuated by the chest wall deformities.

Osteo-cartilaginous malformations and chest wall deformities are recorded in 20% of cases.² Rib hypoplasia and sometimes aplasia can be found. Usually, the sternal insertions of the 2nd to 5th ribs are affected. In severe chest wall deformities, a pectus excavatum of the affected site can be observed.

Chest Wall Personalized Silicone Implants

It is a less invasive technique to correct thoracic wall deformities. In the beginning, a thoracic wall mold was used, but today, the personalized silicone implant is created using a computer and 3-D CT-scan reconstruction. The implant obtained this way corrects the chest wall defect.⁴ In some cases, a fat transfer session can be associated with good final results.

Most often chest wall silicone implants are used in men with Poland syndrome because they do not have as much fat tissue as women do.

Tissue Expanders

Some authors use tissue expanders for breast reconstruction. The expander is placed subcutaneously, as the pectoralis muscle is hypotrophic or absent. Three weeks later, after the wounds are healed, the expander can be inflated progressively with saline, once a week or once every two weeks, depending on the skin quality. Once the desired volume is obtained, hyperexpansion with about 30% more than the contralateral breast is performed, then the expander is left in place up to three months and afterwards during a second surgery the expander is replaced with the definitive breast implant.

The advantage of this method is that it increases the sternum to nipple distance and can partially correct the nipple dystopia. It also enlarges the areola dimensions.

Even though it is a largely accepted and used method, we do not perform this technique, because our main goal is to obtain, if possible, an autologous reconstruction or a result as natural as possible for these patients, who are usually young, in order to avoid additional surgeries later in their life.

Breast Implants

Breast reconstruction can be performed using silicone breast implants directly or after tissue expansion. Because of pectoralis major hypoplasia or agenesis, the breast implant can be positioned only subglandularly or subcutaneously, depending on the mammary tissue status.

For a good result with this technique, the subcutaneous tissue should be thick enough to avoid that the implant is felt and seen under the skin, implant rippling, skin perforations with implant exposure and other associated complications.

Used alone, breast reconstruction with silicone implants in Poland syndrome may accentuate the subclavicular depression, which produces an artificial result. Unilateral implant reconstruction gives a long-term asymmetrical result, and for this reason is not our first choice for breast correction.

We use breast implants in secondary cases, when the initial reconstruction was performed with a silicone implant and the skin quality is acceptable. For these cases we also



• **Fig. 23.5** A secondary case of Poland syndrome in a 45-year-old patient with stage II breast deformity initially corrected with breast implant. (A) Preoperative frontal view. (B) Preoperative $\frac{3}{4}$ lateral view. (C) Two years postoperative frontal view. (D) Two years postoperative $\frac{3}{4}$ lateral view. (E) Two years postoperative dorsal view.

perform one or two sessions of fat grafting and implant replacement (Fig. 23.5).

It is considered a good indication for breast implant reconstruction when the thoracic tissues have good quality, when the patient does not have fat deposits or when the patient requires breast augmentation. We associate one or two sessions of fat grafting with implant reconstruction and

also we recommend contralateral augmentation for the best possible aesthetic result.

Latissimus Dorsi Musculocutaneous Flap

The latissimus dorsi musculocutaneous flap is our preferred technique for breast reconstruction after mastectomy in

association with fat transfer.⁵ In patients with Poland syndrome the prospect of a muscular flap is not well accepted by the patient and her parents given the fact that patients already have muscular malformations. This is why, in our practice, this technique is not the first intention. Since the advent of lipomodeling we have successfully used the latissimus dorsi muscle in association with fat grafting in selected patients. We use the short scar latissimus dorsi musculocutaneous flap in secondary cases that were initially reconstructed with a breast implant and which have poor quality skin and subcutaneous tissues for which conversion to autologous tissue reconstruction is the best option (Fig. 23.5).

In these cases, several surgical interventions are required: the first one is the harvesting of the latissimus dorsi flap with a short scar that stops 2–3 cm behind the posterior axillary fold without adding scars to the breast. The muscle is harvested with the fat found beneath the fascia superficialis. The muscle tendon is completely sectioned to limit muscle contractility. Three months after this surgery fat grafting is performed to increase the breast volume. A supplementary fat grafting session can be performed three months afterwards if required.

Free Flaps

In cases where the latissimus dorsi muscle is absent or is hypotrophic, free flaps can be used. In the past, free contralateral latissimus dorsi, TRAM or gluteal flaps have been used,⁶ but today, their place has been taken by perforator flaps. The DIEP flap can be a good solution in selected cases,⁷ but has few indications because the young patients usually do not have sufficient skin and fat excess in the lower abdomen. Other perforator free flaps like the gluteal perforator flaps – SGAP and IGAP – can be used for the later patients.⁸ The receiving vessels are most often the internal mammary artery and vein that are not affected in the Poland syndrome.⁸

► Fat Grafting (Video 23.1)

The surgery is performed under general anaesthesia. For the first surgery the elected donor site is the abdominal region and for the other surgeries the fat harvested from the thighs and the posterior part of the body is used (Fig. 23.6).

Before surgery, the markings are made with the patient in a standing position: the donor areas are marked and, at the breast level, so are the areas that need fat transfer and the breast limits (inframammary fold, medial and lateral borders and also the cleavage symmetrical to the contralateral breast).

For the fat harvesting we perform the incisions using a no. 15 scalpel, then the tissue is infiltrated with saline–epinephrine solution (1 mg epinephrine in 500 mL saline) in a 1:1 ratio with the desired harvested fat quantity.

The fat is harvested using a multi-hole 3.5 mm diameter cannula linked to 10-mL Luer Lock syringes (Fig. 23.6A). The vacuum into the syringe is controlled by hand and is increased gradually to reduce the trauma produced by the negative

pressure on the adipocytes. The harvested fat is centrifuged at 3000 rotations/min for 20 seconds. After centrifugation in the syringes, three phases can be observed: the lower part is a liquid phase and consists of saline and blood, the middle part is the fat to be transferred, and the upper part is an oil phase and consists of the oil separated from the broken adipocytes (Fig. 23.6B). A nurse removes the liquid and oil and the fat to be transferred is conditioned into 10-mL syringes.

At the end of the liposuction the donor areas are infiltrated with a solution of ropivacaine (Naropaine) to decrease post-operative pain of the donor areas. The incisions are closed with a fast absorbable suture and a small adhesive dressing.

The fat transfer to the breast is performed with the patient slightly seated. The incisions for fat transfer are performed with an 18G trocar and positioned at the level of the inframammary fold and in the periareolar area (Fig. 23.6C).

The fat is transferred using a 2-mm diameter blunt cannula in a criss-cross pattern from the deeper to the superficial layers, until the receiving area is saturated with fat (Fig. 23.6D). The incisions are closed using a fast absorbable suture. Then the dressing is made with fat dressing and gauze without compression.

In the case of Poland syndrome, one has to pay attention to the subclavicular vessels that can be found sometimes lower than in the case of normal anatomy (below the clavicle). In the subclavicular area, we transfer fat very superficially, subcutaneously. At the end of the procedure we check the capillary refill in order to exclude fat embolism. Usually three or more surgeries are necessary. The spacing between surgeries is about three months.^{9–12}

Pectoro-Mammary Flap

It is a technique that uses the mammary gland excess of the contralateral breast to reconstruct the affected side. It is a musculo-glandular flap that includes a part of the pectoralis major muscle and the lower pole of the breast and is pedicled on the thoraco-acromial vessels. The mammary gland vascularization is based on the posterior perforators like for the posterior glandular flap described for breast reduction.

When used for Poland syndrome, it provides central projection that sometimes is difficult to obtain when using only lipomodeling. This flap can be used when the contralateral breast is large enough to require breast reduction. The Wise pattern is drawn as for regular breast reduction. A supero-external glandular flap is used for nipple–areola complex repositioning. The lower part of the breast is harvested together with the central part of the pectoralis major muscle; the acromio-thoracic pedicle is identified and the pectoralis muscle is harvested as a muscular band around the pedicle up to the clavicle. Then, a subcutaneous tunnel is dissected at the manubrium level, to allow the flap transposition to the other side. Before flap transfer, the mammary lodge is dissected through a small incision to the inframammary fold (5 cm long).

Three months after the initial surgery, lipomodeling can be performed for a better result.

The advantage of this technique is that the result is an autologous reconstructed breast without additional donor



• **Fig. 23.6** Lipomodeling technique. (A) Fat harvesting with Luer Lock syringes and 3.5 mm diameter cannulas. (B) Syringe after centrifugation with the three phases: the lower one – saline and blood; the middle one – the fat to be transferred; and the upper one – the oil. (C) Incisions made with the 18G trocar. (D) Fat transfer with the 2-mm diameter cannula.

sites. The technique is difficult and it requires an experienced surgeon.

Case Examples

CASE 23.1

A 21-year-old patient with a stage I Poland syndrome breast deformity (see Fig. 23.1). The patient had four lipomodeling sessions: 260 mL, 430 mL, 455 mL to the left breast and 60 mL to the right breast, and 310 mL. In Fig. 23.1C,D, the result at 2 years after the last lipomodeling can be observed.

CASE 23.2

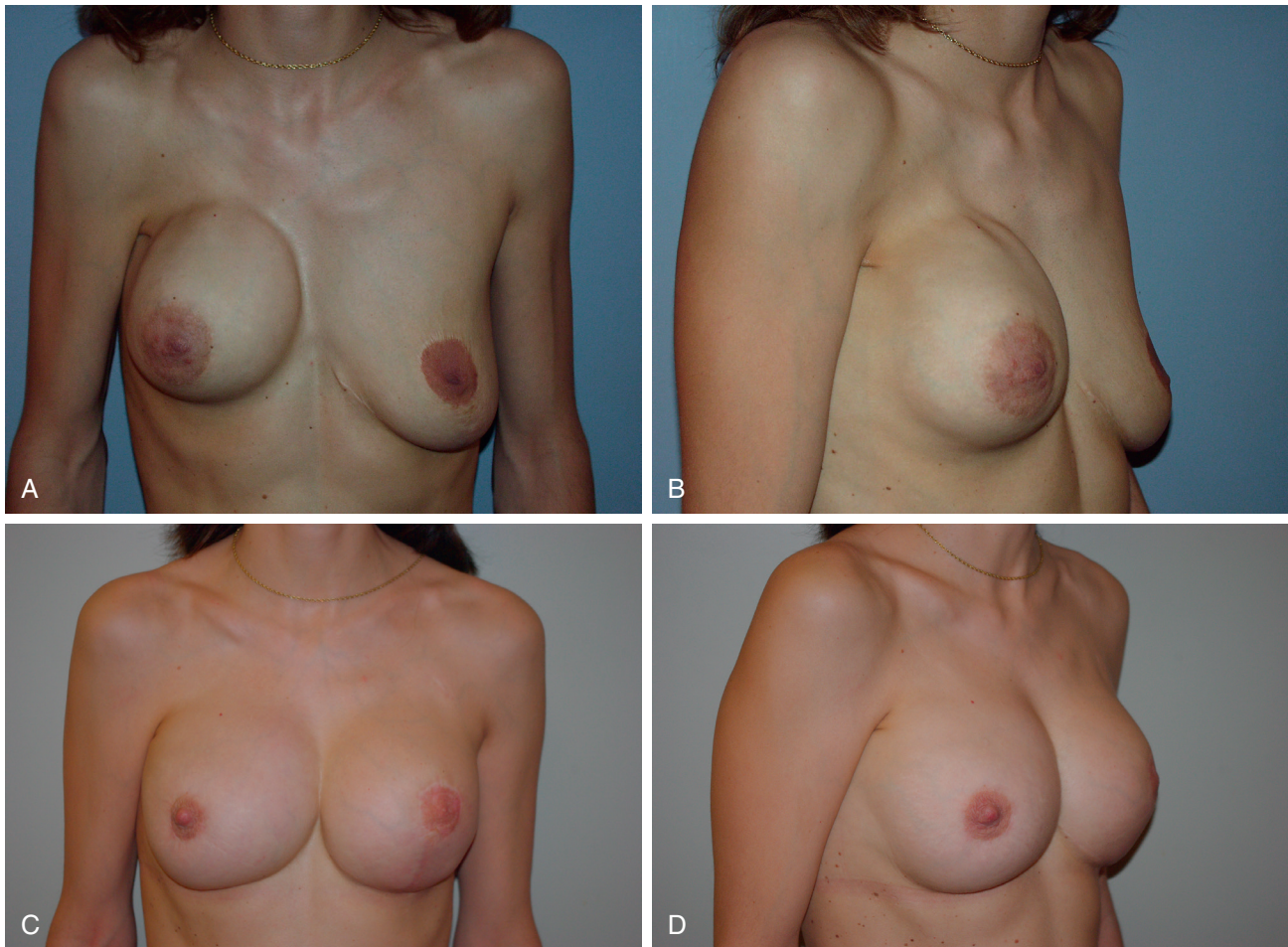
A 15-year-old patient with stage II Poland syndrome breast deformity (see Fig. 23.2). The patient had three lipomodeling sessions: 197 mL, 300 mL and 350 mL. In Fig. 23.2C,D, the result at 1 year after the last lipomodeling can be observed.

CASE 23.3

A 12-year-old patient with stage III Poland syndrome breast deformity (see Fig. 23.3). The patient had five lipomodeling sessions: 127 mL, 209 mL, 82 mL, 206 mL and 185 mL. The duration of the surgical treatment was about two years. Fig. 23.3C,D shows the patient 1 year after the last operation. Fig. 23.3E,F shows the patient at 11-year follow-up. Because she gained 5 kg, we can observe that the reconstructed breast is bigger but she remains satisfied with the result.

CASE 23.4

A secondary case of Poland syndrome in a 50-year-old patient with stage II breast deformity, initially corrected with breast implant. The patient requested correction of the asymmetry and cleavage improvement. The correction was made by a lipomodeling session of 222 mL and three months later by a second lipomodeling session of 220 mL and implant replacement. Fig. 23.7C,D shows the result 1 year after the last surgery.



• **Fig. 23.7** A secondary case of Poland syndrome in a 50-year-old patient with stage II breast deformity, initially corrected with breast implant. (A) Preoperative frontal view. (B) Preoperative $\frac{3}{4}$ lateral view. (C) One year postoperative frontal view. (D) One year postoperative $\frac{3}{4}$ lateral view.

CASE 23.5

A secondary case of Poland syndrome in a 45-year-old patient treated with prosthesis. The skin of the lower pole was very thin with a high risk of implant exposure. An autologous conversion was performed with the latissimus dorsi and two months later fat transfer of 376 mL of fat grafts. Fig. 23.5 shows the final result two years after reconstruction.

Postoperative Care and Expected Outcomes

When lipomodeling is performed, the dressing is simple: non-compressive fat dressing for about two weeks. Given the fact that the liposuction is not very important quantitatively, we do not recommend compressive dressings on the donor sites. The patient is advised to avoid compressing the operated breast and to avoid strenuous effort for about one month. We always explain to patients that the result

obtained after surgery is going to diminish: partly because of oedema reduction and also because 30% of the transferred fat is going to be lost. In the postoperative period, the pain is mainly linked to the donor sites that require simple analgesics. Ecchymosis is developed on the donor sites and milder ones on the operated breast and this will subside after 2–3 weeks.

When associated with breast implant, we use a drain for about two days and the hospital stay is longer. Recommendations are similar to those of breast implants in augmentation surgery.

When a latissimus dorsi flap is used, the hospital discharge is on the postoperative day 4. A compressive dressing is made at the end of surgery in the dorsal region without applying pressure on the axillary and upper lateral thoracic regions where the pedicle passes. When the patient is discharged, the compressive dressing is removed and a simple dressing of the incision is used. The drains to the breast (one under and one above the flap) are removed before discharge and the dorsal drain only if the quantity drained in 24 h is 50 mL or less; if not, the drain is removed later on. The

pain is more important and this surgery requires more potent analgesics. Physical activity and arm movements are reduced for 1–1.5 months.

The outcome is usually simple. There is a low incidence of complications linked to lipomodeling, most often oily cysts that are treated by puncture if they are bothering the patient. The recovery may take up to 2 weeks, when patients feel tired; for the latissimus dorsi reconstructions the recovery is slower because of more postoperative pain. When the reconstruction is completed with autologous tissue, patient satisfaction is very high. If the patient maintains her weight, the result remains constant. With weight gain, the reconstructed breast can become larger than the contralateral breast (see Fig. 23.3E,F) and can be treated with liposuction later on. When breasts are reconstructed with prosthesis, we prefer to combine it with lipomodeling in order to increase the autologous tissue:implant ratio and reduce the incidence of delayed implant-linked complications.

In our series, patient satisfaction is very high.

Management of Complications

In our series of Poland syndrome breast deformities we had no complications.

The major complications linked to the fat transfer can be extremely rare: pneumothorax, abdominal perforation, fat embolism. The minor complications are: local infection that can be addressed with common antibiotics (erythema, increased temperature and pain, rarely purulent discharges through the small incisions); fat necrosis manifested as painful, indurated areas of the breast – this can be addressed when performing an additional fat transfer when the necrosis can be drained and replaced with new fat grafts; oil cysts that can be sometimes felt under the skin – they can be punctured and the oil drained, and if they are deep, they can just be left untouched and surveyed regularly by ultrasound.

When implant reconstruction is used, the complications linked to breast implants can appear: hematoma, seroma, infection, implant rippling and visibility through the thin skin (this can be addressed by associating lipomodeling with breast implant reconstruction), and capsular contracture.

When a latissimus dorsi flap procedure is performed, the classical complications described for this flap can develop: pneumothorax, partial flap necrosis (extremely rare, because the latissimus dorsi is a very reliable and resistant flap), hematoma, dorsal seroma (today we have almost no donor-site seroma due to our technique of quilting suture after flap harvesting), infection, dorsal chronic pain, and flap contraction.

Secondary Procedures

The secondary procedures are used when treating patients that have already been operated on by another team several years before. The patients usually had implant reconstruction

or expander–implant reconstruction, or in some cases a latissimus dorsi flap and implant.

Two situations can be described:

- There is good covering and good tolerance of the breast implant. In these cases, we keep the implant reconstruction and we perform one or two lipomodeling sessions to improve the cleavage and the thickness of the tissues covering the implant (see Fig. 23.7).
- The implant is not well tolerated; the skin is thin and has an important risk of implant exposure, or when capsular contracture is present. In these cases, the reconstruction should be converted into autologous, and most often we use the short scar latissimus dorsi musculocutaneous flap with one or two lipomodeling sessions (see Fig. 23.5). We can also use a pectoro-mammary flap, but usually the contralateral breast has already been operated on. In selected cases, a free flap procedure can be performed.

Conclusions

Poland syndrome is rare and its breast deformities are usually complex and difficult to treat. Many surgical techniques have been described for the correction of these deformities with more or less success. Lipomodeling is a primary procedure for these patients because it provides an autologous reconstruction with natural sensation and consistency of the breast. When the fat tissue is not sufficient, fat grafting can be performed in combination with a breast implant or a flap for a better aesthetic result. It is our opinion that lipomodeling is the new best indication for the treatment of breast deformities, because it can be performed as outpatient surgery, without severe pain, and with minimal scars and low complication rates.

PEARLS FOR SUCCESS

- Lipomodeling is in our opinion the best solution for breast deformity corrections, but it requires a learning curve that is better to be completed with easier cases, such as cases of breast reconstruction after mastectomy.
- Mild forms can be treated with 3 or 4 lipomodeling sessions if the patient has enough fat.
- In cases when the patient desires breast augmentation, two lipomodeling sessions can be combined with implant breast reconstruction and contralateral breast augmentation.
- When autologous reconstruction is desired and there is not enough fat or the chest wall hypoplasia does not support an implant, short scar latissimus dorsi musculocutaneous flaps, pectoro-mammary flaps or free flaps can be used in combination with lipomodeling for a better result.
- In secondary cases, when the tissues are of good quality, implant replacement and one or two sessions of lipomodeling can be performed to improve the result.
- In secondary cases when the tissues are of poor quality, autologous conversion with a latissimus dorsi flap, pectoro-mammary flap, or free flap should be considered.

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24

Correction of Tuberous Breast Deformity

ADAM R. KOLKER AND PAUL L. SHAY

Introduction

Tuberous breast deformity is a congenital anomaly with widely variable morphologic presentation. The etiology remains uncertain, although it is postulated that the deformity has an embryologic origin¹ with a possible genetic predisposition;² however no clear link has yet been determined. The physical manifestations of tuberous breasts have been attributed to periareolar fibrous ring constriction and hypoplastic, elastic areolar fascial support, the combination of which predisposes to narrow ventral-vector development of the breast bud into a more pliable and less resilient areola, resulting in a peripherally constricted appearance of portions of the breast with herniation of the areolar complex (Fig. 24.1). The most frequently observed characteristics of tuberous breast deformity include breast base constriction, parenchymal hypoplasia, lower pole skin deficiency, superior malposition of the inframammary fold (IMF), areolar herniation, and ptosis, as demonstrated in Fig. 24.2. The physical manifestations can vary widely in severity, with one, several, or all of these features present (Fig. 24.3). Asymmetry is also a frequent hallmark of tuberous breast deformity, with discrepancies seen in breast size, shape, areolar dimension and herniation, and degree of ptosis.³

Tuberous breast deformity can present exceptional challenges for surgeons as much from the subtle cases as the severe. The technical demands of enhancing or creating a lower breast pole, controlling areolar herniation, correcting ptosis, and improving symmetry of breast size, shape and areolar dimensions are frequently substantial. Tuberous breasts are often underappreciated and underdiagnosed, with patients often expecting, and surgeons regrettably performing, a standard breast augmentation.

Identification and classification of the presence and severity of each feature of the deformity, or combination thereof, is critical in the establishment of a treatment plan. Von Heimburg,⁴ Grolleau,⁵ Meara,⁶ and Costagliola⁷ have proposed classification systems to define the spectrum of tuberous breast deformity. We prefer employing a three-tiered classification⁸ that incorporates the specific pathologic

hallmarks of the deformity (Fig. 24.4), and that facilitates the formulation of a treatment strategy that can be tailored on an individual basis to all patients based on morphology and deformity severity (Table 24.1).

The keys to success in tuberous breast correction include the interruption of the fibrous ring constriction, release and expansion (in one or more stages) of lower pole deficiency, establishment of an appropriately positioned IMF, overcoming pre-existing IMF memory, augmenting the deficient lower pole for both volume and shape maintenance, reduction of areolar herniation, balancing areolar dimensions, correcting ptosis, and correcting asymmetry.

Indications and Contraindications

Women with any degree of tuberous breast deformity may be candidates for surgical correction, as the effects of the developmental anomaly are most often psychological, related to the self-perception of having “abnormally shaped” breasts. Ideal candidates are women with tuberous breast deformity who have completed breast development, and optimally have been at a plateau of stable breast shape and size for one year. Around 18–19 years is a common age for initial consultation and treatment. Consideration may occasionally be given to younger girls (15–17 years) with marked asymmetry, deformity or extreme emotional distress, with the caveat that continued breast development may increase the likelihood of a secondary surgery. In such cases, particularly in those with unilateral severe hypoplasia, the use of tissue expanders or adjustable implants may be beneficial to remain apace with potential progressive breast growth. Surgery before 15 years of age is not recommended.

Not unique to women, tuberous breast deformity is also seen in men as a variant of gynecomastia with periareolar fibrous ring constriction and areolar herniation.⁹ The technical considerations in male tuberous deformity differ in that the treatment is entirely reductive, and no effort is required to release, augment or enhance the breast lower pole.

TABLE 24.1 Classification of Tuberous Breast Deformities

Type	Base	Inframammary Fold	Skin Envelope	Breast Volume	Ptois	Areola
I	Minor constriction	Normal laterally, minor elevation medially	Sufficient	Minimal deficiency, no deficiency, or hypertrophy	Mild, moderate, or severe	Enlargement
II	Moderate constriction	Medial and lateral elevation	Inferior insufficiency	Moderate deficiency	None or mild	Normal, mild or moderate herniation
III	Severe constriction	Elevation of entire fold, or fold absence	Global insufficiency	Severe deficiency	Mild/moderate	Severe herniation

(Reproduced from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg*. 2015;135(1):73–86, Table 1.)



• **Fig. 24.1** Characteristics of tuberous breast deformity, including breast base constriction, parenchymal hypoplasia, lower pole skin deficiency, superior malposition of the inframammary fold (IMF), and areolar herniation.

Preoperative Evaluation

Detailed history and physical examination include measurements of breast dimensions and careful evaluation of breast base constriction, IMF position, skin envelope sufficiency and distensibility, breast mass, ptosis, areolar herniation, and any asymmetry. Of foremost importance in the treatment of tuberous breast deformity is the careful identification and stratification of all anatomic features. This assessment facilitates the categorization of each patient using the three-tiered classification system, and to further establish a treatment algorithm tailored to specific needs of the individual. [Fig. 24.5](#) demonstrates the algorithm that is used to establish a

treatment strategy for each patient based on the anatomic features noted above as well as the patient's desires.

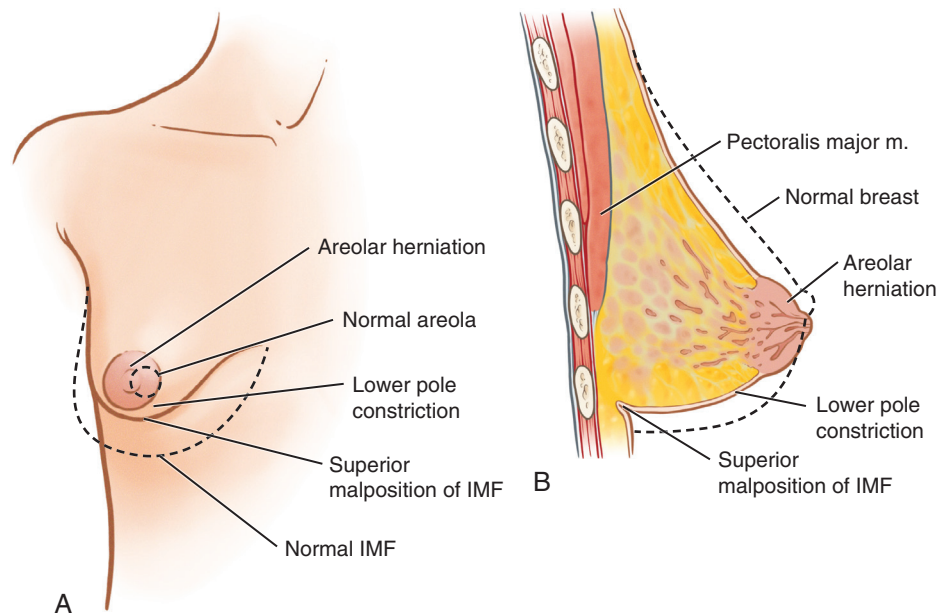
Surgical Techniques

Relevant Surgical Anatomy

The pathologic anatomy of tuberous breast deformity is demonstrated in [Fig. 24.2](#). The anatomic hallmarks can manifest as mild, moderate or severe expressions of the following: constriction of the breast base, hypoplasia or hyperplasia of breast parenchyma, skin deficiency of the breast lower pole, a high-riding or superiorly malpositioned IMF, herniation of the areolar complex, and ptosis. The surgical options for treatment are informed by the presence and severity of the individual features. Once carefully identified, the authors' treatment algorithm ([Fig. 24.5](#)) aids in addressing each facet of the deformity and the establishment of a surgical treatment plan.

Classical Technique Descriptions

Historically, the approaches to tuberous breast deformity correction have included a variety of incisional access sites (areola, IMF, axillary) and multiple techniques for parenchymal reshaping, and methods to control areolar herniation. Rees and Aston¹⁰ favored prepectoral implant insertion and circumareolar mastopexy in the setting of herniation of the areolar complex, and inframammary incisions with glandular scoring and prepectoral implant placement in the setting of constricted breast base. In 1990, Puckett and Concannon¹¹ described an “unfurling” technique using a periareolar access incision, performing a subcutaneous plane dissection of the lower pole, followed by subglandular dissection to the mid-point of the breast mound. The breast parenchyma is then “split” horizontally from its deep surface, creating a superiorly based glandular flap that is “unfurled” and sutured to the inferior pole after placement of a subpectoral implant. Ribeiro and colleagues¹² described a circumareolar de-epithelialization, after which the breast parenchyma is



• **Fig. 24.2** Anatomical features of tuberous breast deformity. IMF, inframammary fold. (Reproduced, in part, from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg.* 2015;135(1):73–86, Figure 2.)

dissected down to prepectoral fascia to create superior and inferior breast flaps. The inferior breast parenchyma is then dissected free from the overlying subcutaneous tissue. The medial and lateral “prolongations” of the inferior glandular flap are excised, helping to disrupt the fibrous ring. The inferior glandular flap is then folded over itself to improve lower pole fullness and breast projection. The circumareolar incision is then closed using a round-block suture technique. We have found the majority of these approaches dissatisfying in the achievement of consistent results.

Among the fundamental underpinnings of our strategy are periareolar access, transglandular dissection, and radial glandular scoring, all of which play a role in releasing the fibrous ring constriction that is present to varying degrees in all tuberous breast morphology. We have found little utility in the use of parenchymal flaps, and prefer bisection of the gland through the areolar access, maintaining a lower pole “dermoglandular flap” that can be addressed with scoring maneuvers to improve shape. We favor a dual plane dissection and positioning of all breast implants for tuberous correction, and employ interlocking circumferential purse-string sutures for control of areolar herniation.

Periareolar Access Incisions

The periareolar approach affords the most flexibility and predictability, and we employ this approach exclusively for the correction of tuberous breast deformities. Areolar access is superior to an IMF incision because the final location of the new IMF is often extremely difficult to precisely determine, and an areolar incision obviates an inframammary scar that can be superiorly or inferiorly malpositioned. Additionally, the areolar approach also affords access to a dissection plane directly through the subareolar breast

parenchyma, effectively releasing any internal glandular ring constriction that may exist with the deformity. Finally, any areolar positional asymmetries, shape abnormalities, and herniation are readily adjustable via the areolar approach.

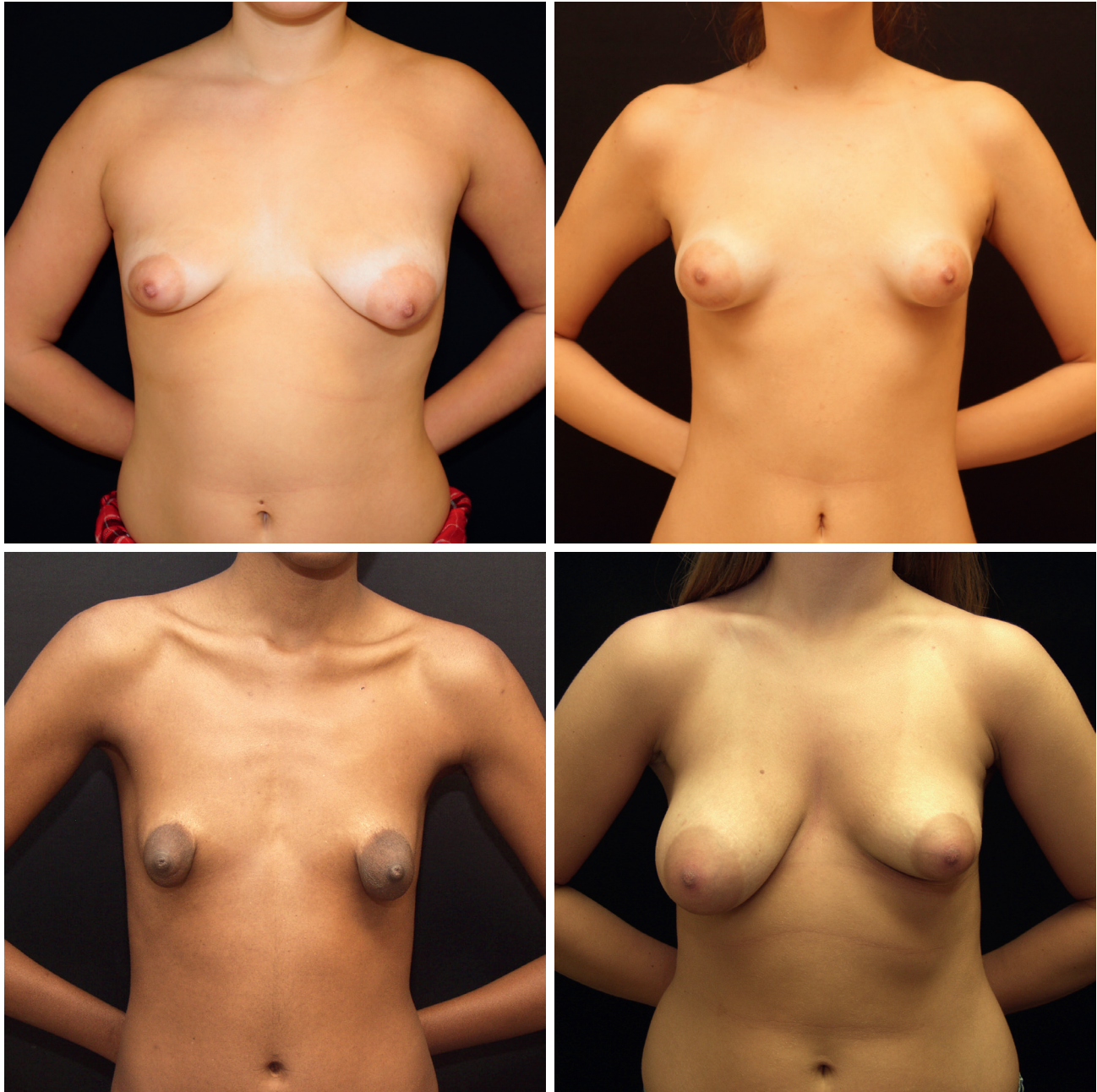
Transglandular Dissection and New IMF Definition

Through the areolar incisional approach, dissection in a perpendicular fashion through the gland establishes a lower pole dermoglandular flap that allows for both contouring of the lower pole and for maintenance of soft tissue coverage. This initial dissection directly through the gland effectively bisects the gland in an equatorial plane, “breaking the ring” in two places. (When cutting a ring with any integrity in one place, it is likely to maintain its shape, and a minimum of two cuts are required to “break” its circular form to allow it to be more easily reshaped). Further constriction release and additional “break-points” in the “ring” are later created with incisions made radially, perpendicular to the vector of constriction, helping to more reliably overcome the memory of the pre-existing deformity.

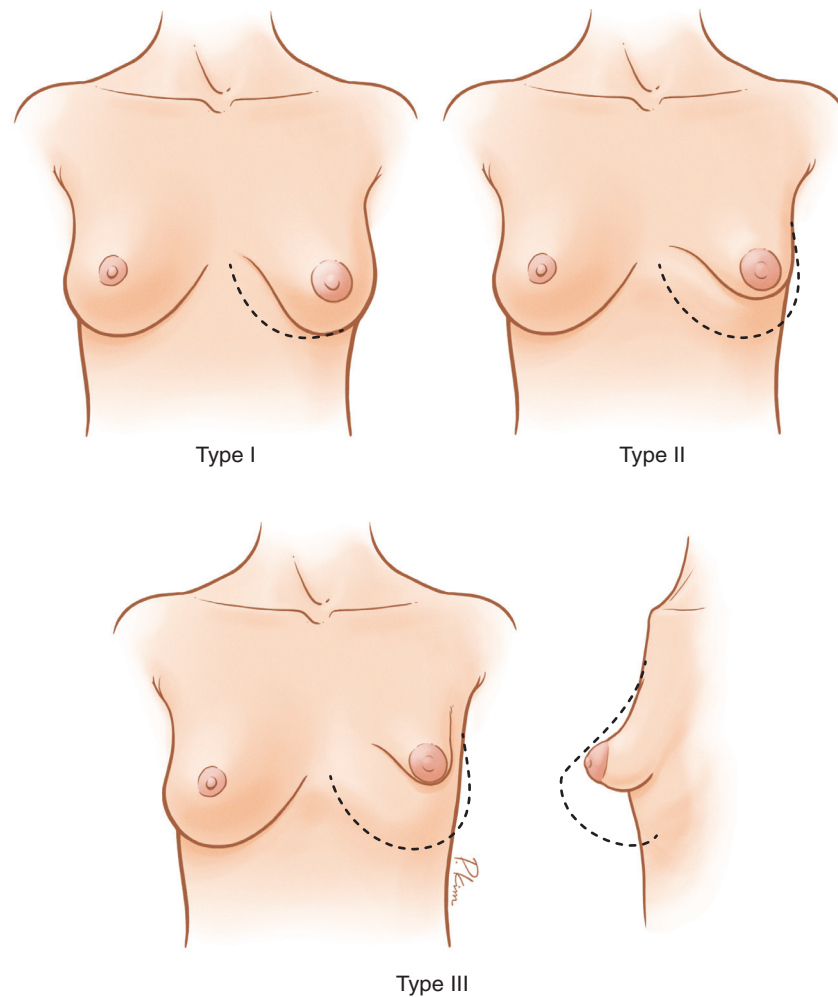
After dissecting through the breast parenchyma to the prepectoral fascial plane, dissection is further developed inferiorly to the proposed new limit of the breast lower pole. Care must be taken not to undermine past this proposed line; it is simple to adjust inferiorly if necessary and considerably more difficult and time consuming to re-establish if disrupted. This initial prepectoral dissection also serves as the first component of the dual plane dissection.

Radial Scoring

The release of glandular and breast base constriction with radial scoring maneuvers is employed in all cases. With the



• **Fig. 24.3** The varied presentations of tuberous breast deformity, illustrating diverse degrees of breast base constriction, parenchymal hypoplasia and hyperplasia, lower pole skin deficiency, IMF malposition, areolar herniation, ptosis, and asymmetry.



• **Fig. 24.4** Classification of tuberous breast deformity. Type 1, hypoplasia of the lower medial quadrant; type II, hypoplasia of the lower medial and lateral quadrants; and type III, severe breast constriction and global hypoplasia. (Reproduced from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg.* 2015;135(1):73–86 Figure 1.)

deep surface of the gland exposed, electrocautery scoring of the gland is performed. The constricting horizontally oriented fascial bands within the gland lower pole and along the pre-existing IMF are incised in a perpendicular (vertical/radial) fashion from the deep subglandular plane, progressing superficially to the point of release. The periareolar transglandular approach is invaluable for facilitating the exposure to this lower pole subglandular plane, and for radially dividing the fascial constriction. The extent and depth of scoring is predicated on the degree of constriction, and the endpoint is the expansion of the breast lower pole and the visual release of any pre-existing, native IMF memory. In cases of more severe soft tissue and native fold constriction, the radial scoring maneuvers can be carried to the subdermal plane if necessary.

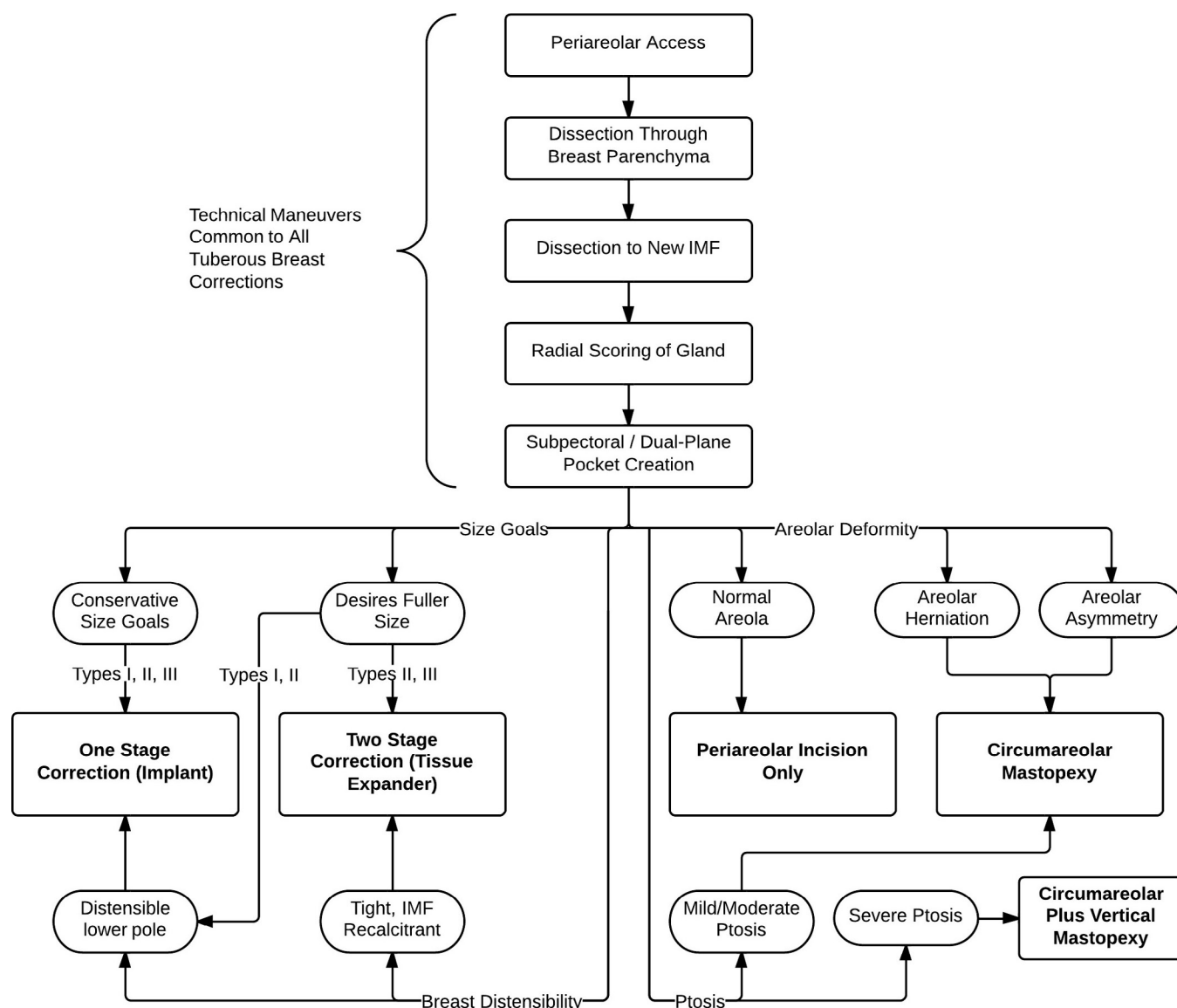
The glandular parenchymal division and scoring maneuvers over a large surface area are often productive of

considerable serous fluid effluent, hence closed suction drains are used in all cases. Volumes are not uncommon.

Implant versus Autologous Reconstruction

Despite accounts of breast glandular division and transposition,⁵ we feel that the amount of breast parenchyma is often diminutive, and have found only rare circumstances with enough autologous breast tissue to satisfactorily augment the hypoplastic lower pole. Breast implants are standard-of-care in cases of micromastia or relative hypoplasia for the purposes of augmenting breast size, improving lower pole shape, and long-term maintenance of the constriction release achieved by radial scoring maneuvers and re-establishment of a new IMF position.

While autologous fat grafting has been described as an augmentation modality in tuberous breast correction, consistency of outcomes and patient satisfaction have



• **Fig. 24.5** Treatment algorithm for correction of tuberous breast deformity. IMF, inframammary fold. (Reproduced from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg.* 2015;135(1):73–86, Figure 3.)

been found to be limited compared to implant based correction.¹³

Dual Plane versus Subglandular

From the earliest reports of tuberous breast deformity correction, and prevailing today, the most common position for placement of an implant has been in the subglandular space.¹⁰ Subglandular placement enables the prosthesis to shape and expand the breast without being restricted by the pectoralis major muscle. Unfortunately, the negative sequelae of subglandular implant placement, including increased contracture rates, visible implant margins and rippling, late malposition, and unnatural breast appearance¹⁴ can ensue, and may be even more prevalent after tuberous breast correction as a result of the necessary scoring

and thinning of the parenchyma. This is why dual plane augmentation¹⁵ is our preferred approach.

In consideration of the relationship of the pectoralis muscle to the gland and the implant during subpectoral breast augmentation, it is clear that to varying degrees all submuscular breast augmentations are dual plane by definition, with the implant in the breast lower pole effectively subglandular, and in the upper pole submuscular. In tuberous deformity correction in particular, the lower pole is the region of the breast that requires the most “expansion” and implant-related shape definition, with little need for more aggressive fill and expansion of the upper pole, hence dual plane submuscular augmentation is ideal. Dual plane maneuvers also result in the cranial shift of the inferior incised margin of the muscle, away from the region of the

released pre-existing IMF. The result is an uninhibited fill of the lower pole, while promoting the many advantages of submuscular augmentation including softer, more natural contour of the upper pole, increased soft tissue coverage, more durable breast position, and decreased capsular contracture rates.¹⁴ Additionally, with our technique of preserving the inferomedial origins of the pectoralis major muscle, muscle coverage of the implant along the décolletage maintains a natural appearance.

Implant Selection

For one-stage tuberous breast correction, there are only subtle differences in the use of silicone gel implants vs saline implants, or round cohesive gel implants compared with anatomic form-stable highly cohesive gel implants; we feel the implant choice may be the least consequential of all of the steps of the multifaceted process. Nevertheless, we currently favor highly cohesive gel form-stable implants for use in most one-stage tuberous breast corrections. These firmer anatomic implants, with increased silicone crosslinking and greater cohesivity, may confer an advantage of exerting more direct force on the breast base and lower pole, thus maximizing the stretch of the released tissues. These implants also appear to be associated with a low incidence of rippling and capsular contracture.¹⁶ It should be noted that our previously reported experience⁸ using smooth round cohesive gel implants exclusively yielded acceptable and consistent aesthetic results, high degrees of patient satisfaction, and modest complications, and these implants remain a viable option for correction. When two-stage correction is undertaken, the final implant selection at the second stage exchange procedure is even less critical as the expansile “work” has already been achieved by the tissue expander.

One versus Two Stage

Correction in one stage is achieved in the majority of cases. When deficient lower pole skin and soft tissue is distensible, and particularly when size goals are conservative, single stage correction is most often attainable. In cases of moderate and severe breast hypoplasia (types II and III) where there is severe constriction of the skin envelope and a tight, recalcitrant IMF, or if the patient desires a fuller result than the deficient lower pole skin and soft tissue will allow in one stage, two-stage correction with tissue expander placement is advisable. In instances where it becomes clear intraoperatively, despite all radial scoring maneuvers, that the pre-existing IMF memory cannot be overcome sufficiently during the first stage, tissue expander insertion is recommended. Additionally, two-stage correction can provide for a planned return for a “second look,” enabling adjustments in areolar position and shape, and fine-tuning of breast symmetry.

One of the more arduous tasks in the selection of a two-stage approach with expanders is patient education. We uniformly have tissue expanders available for cases wherein the lower pole and inframammary crease distensibility is in question, and educate patients accordingly. While every effort is made to achieve safety and consistency in aesthetic

results in one stage, it is better for both surgeon and patient to strive toward a superior result in two stages than a sub-optimal outcome, subject to the likelihood of revision surgery, in one.

Mastopexy and Asymmetry Considerations

Breast ptosis requires clear identification in every case when formulating a treatment plan. We have found that more classical grading of breast ptosis (grade I, II, III, pseudoptosis) does not adequately aid in the description and treatment planning of tuberous ptosis. With inframammary crease malposition, deficiency of lower pole skin and soft tissue, and frequent enlargement, malposition and herniation of the areola, we commonly see relative glandular hypertrophy and breast ptosis that defies standard classification. With the areolar position well below the pre-existing IMF, suggesting a grade II or III ptosis, the nipple-to-IMF distance is often quite short in tuberous breast deformity. Whereas short-scar, circumvertical mastopexy incisions or extended incisions may be required for non-tuberous moderate and high grade ptosis, more limited incisions are often sufficient in tuberous ptosis. After the often necessary maneuvers to lower the IMF and recruit and expand the lower pole, the “lift” of the breast and areola can often be adequately managed with a circumareolar incision.

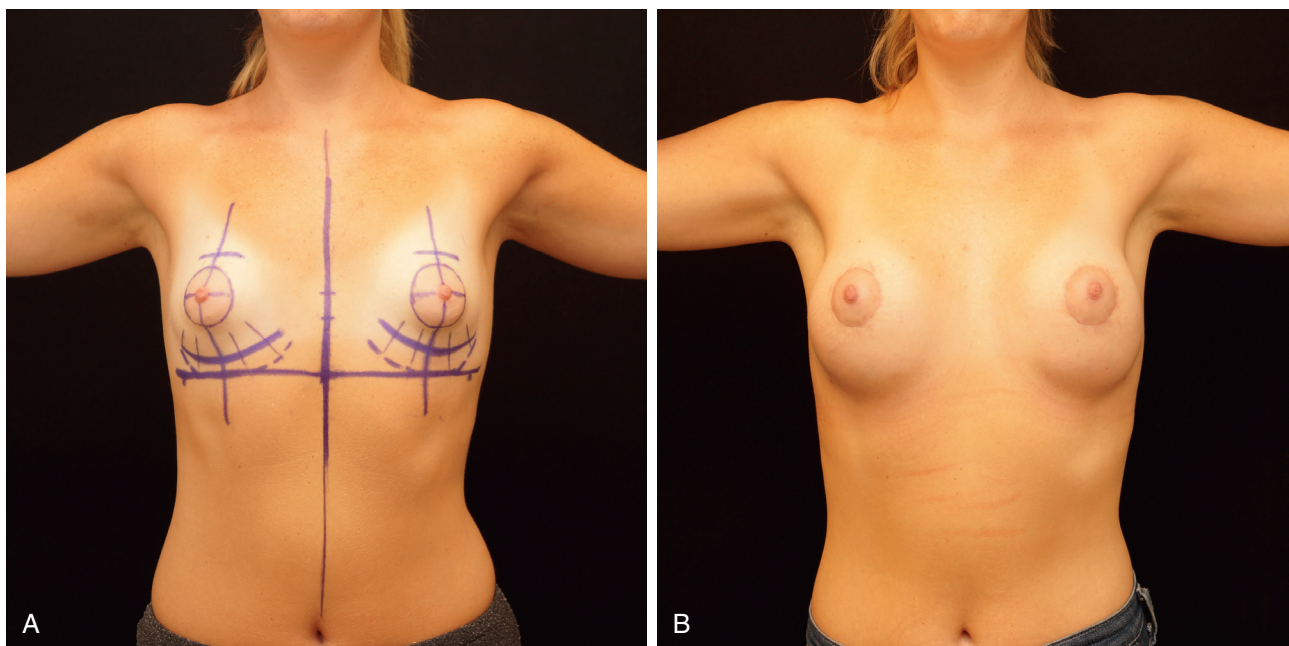
Breast size asymmetry is adjusted with the selection of different implant volume, projection, or both, and/or by the removal of excess gland from the larger breast. We use gland excision when possible, as it affords the opportunity to remove a saucer or wedge of parenchyma from the deepest aspect of the subareolar gland (which may minimize the herniation), and keeps the implant sizes more similar, theoretically lending to longer-term durability of results, however the amount that can be safely removed is generally less than 30–40 g. Suction-assisted lipectomy can be employed in select cases, however this option is frequently limited given the relative youth of this patient population and attendant significant breast glandular density.

Areolar Herniation Control

When areolar herniation and deformity are identified, a circumferential approach is warranted. Round-block suture technique has been described for both circumareolar mastopexy and for reducing areolar diameter and projection.¹⁷ We have employed the interlocking purse-string suture technique described by Hammond,¹⁸ which has promoted consistency in areolar diameter as well as excellent correction by a more uniform flattening of the areolar projection.

Preoperative Markings

All patients are marked preoperatively in the upright position. A vertical midline is marked from the sternal notch through the xiphoid process and to the mid-epigastric midline. The existing IMF lines and the periphery of the areolar-complex margins are then marked. With the patient's arms elevated above her head, the level of the nipple is



• **Fig. 24.6** (A) Preoperative markings for tuberous breast correction. The horizontal reference line and marking for the new IMF position are determined by dividing the breast base dimension measurement by two (the proposed breast “radius”), and transposing this distance inferiorly from the anticipated postoperative position of the nipple–areola complexes, established with the arms abducted at or above 90 degrees. (B) Eight-week follow-up demonstrating early lower pole shape improvement following tuberous breast correction in a 26-year-old woman with bilateral type II tuberous breast deformity, circumareolar mastopexy, dual plane placement of Allergan style 410 anatomic highly cohesive form-stable silicone gel implants, MF-255 (255 cc).

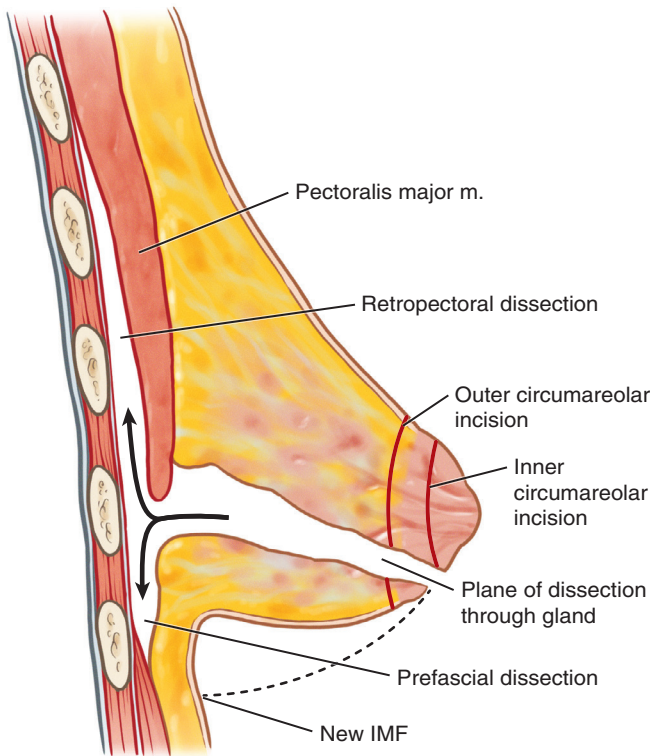
transposed to the midline. A caliper is then used to measure the breast base; one half of this number (the “radius”) is then calculated, and this measurement is transposed to the midline to establish the level of the new IMF. A horizontal line is then drawn through this point, perpendicular to the vertical plumb line, and across the anterior chest beneath each breast. Limits of planned dissection, locations of glandular scoring, and proposed periareolar/circumareolar patterns are marked, and anticipated adjustments of areolar size or position are also marked (Fig. 24.6).

Surgical Exposure and Details of the Procedure

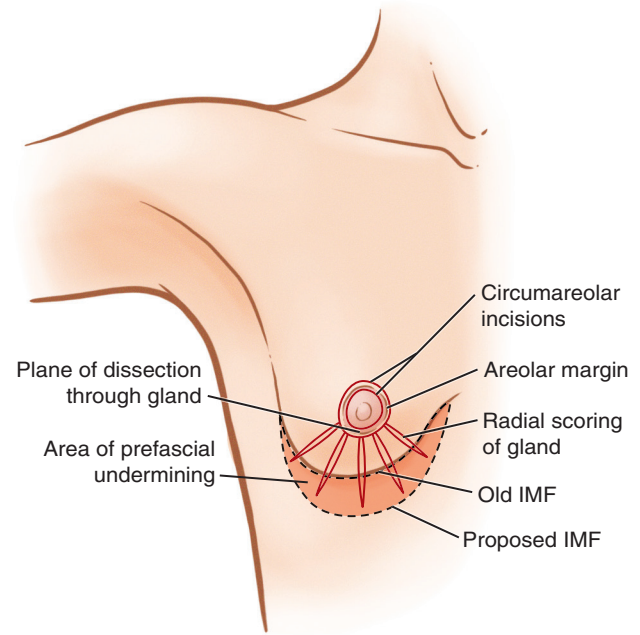
All tuberous breast deformity surgery is performed under general anesthesia (endotracheal or laryngeal mask airway). A periareolar incisional approach is used in all cases. When control of areolar position, shape, or herniation is required, or when breast ptosis correction is required, circumareolar mastopexy is performed with the scoring of concentric circular incisions to include the excess areola. In the absence of significant areolar pathology, a periareolar incision only is used. Concentric areolar reduction/mastopexy, as is required in the majority of cases, is performed after marking and scoring the areola with a Freeman areolar marker (cookie-cutter) at 42–45 mm with the breast placed on stretch by the

assistant. The periphery of the often-enlarged areola is scored, and the intervening “donut” of redundant areola is de-epithelialized. An incision is made with electrocautery from 4 o’clock to 8 o’clock within the de-epithelialized dermis which is deepened into the subcutaneous plane. Dissection then progresses in a perpendicular fashion through the gland directly to the prepectoral fascia. This effectively releases the periareolar fascial constriction that is in large part responsible for areolar herniation. Prepectoral dissection is then carried inferiorly to the limits of the pre-marked new IMF line. Dissection progresses to at least the level of the origin fibers of the pectoralis major in all cases. This maneuver serves as the anterior portion of the dual plane dissection. The pectoralis major muscle is then horizontally incised at its most inferior origin-fiber margin, and a retropectoral dissection plane is developed with electrocautery (Fig. 24.7). Retropectoral dissection then progresses in a stepwise fashion, elevating the muscle medially and cranially first, and subsequently progresses from medial to lateral allowing for easy identification of the pectoralis minor muscle as it is maintained deep to the plane of dissection.

Radial scoring of the gland of the inferior dermoglandular flap is then performed with electrocautery; the endpoint of this dissection is the appropriate expansion and release of the lower pole constriction and overcoming the “memory” of the previous IMF line. Three to five “scorings” are often



• **Fig. 24.7** Illustration of surgical technique for tuberous breast correction, demonstrating the periareolar transglandular approach to the prefascial and retropectoral plane. IMF, inframammary fold. (Reproduced from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg.* 2015;135(1):73–86, Figure 5.)

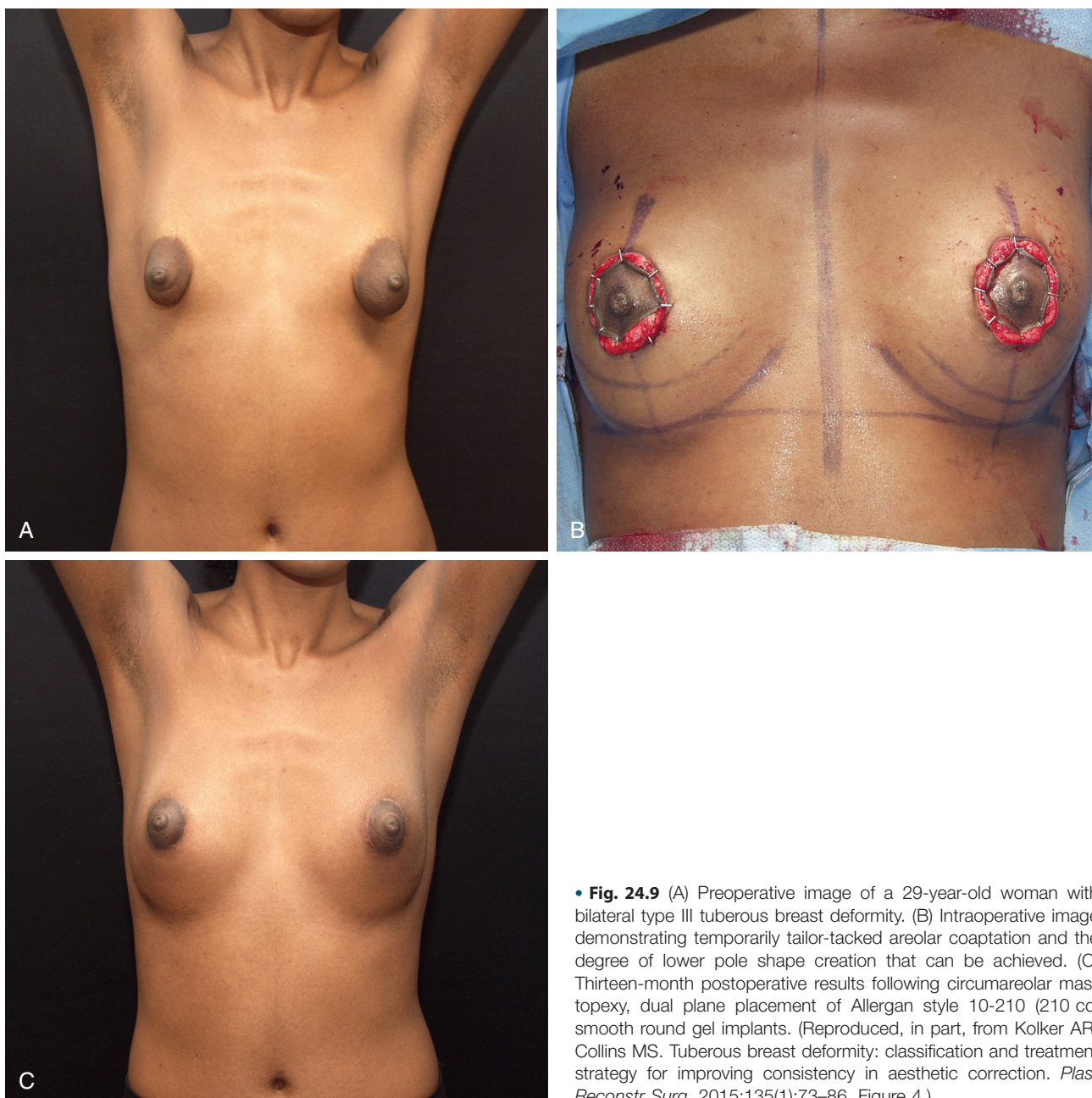


• **Fig. 24.8** Illustration of surgical technique for tuberous breast correction, demonstrating radial scoring maneuvers for the release of glandular and native inframammary fold constriction. IMF, inframammary fold. (Reproduced from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg.* 2015;135(1):73–86, Figure 6.)

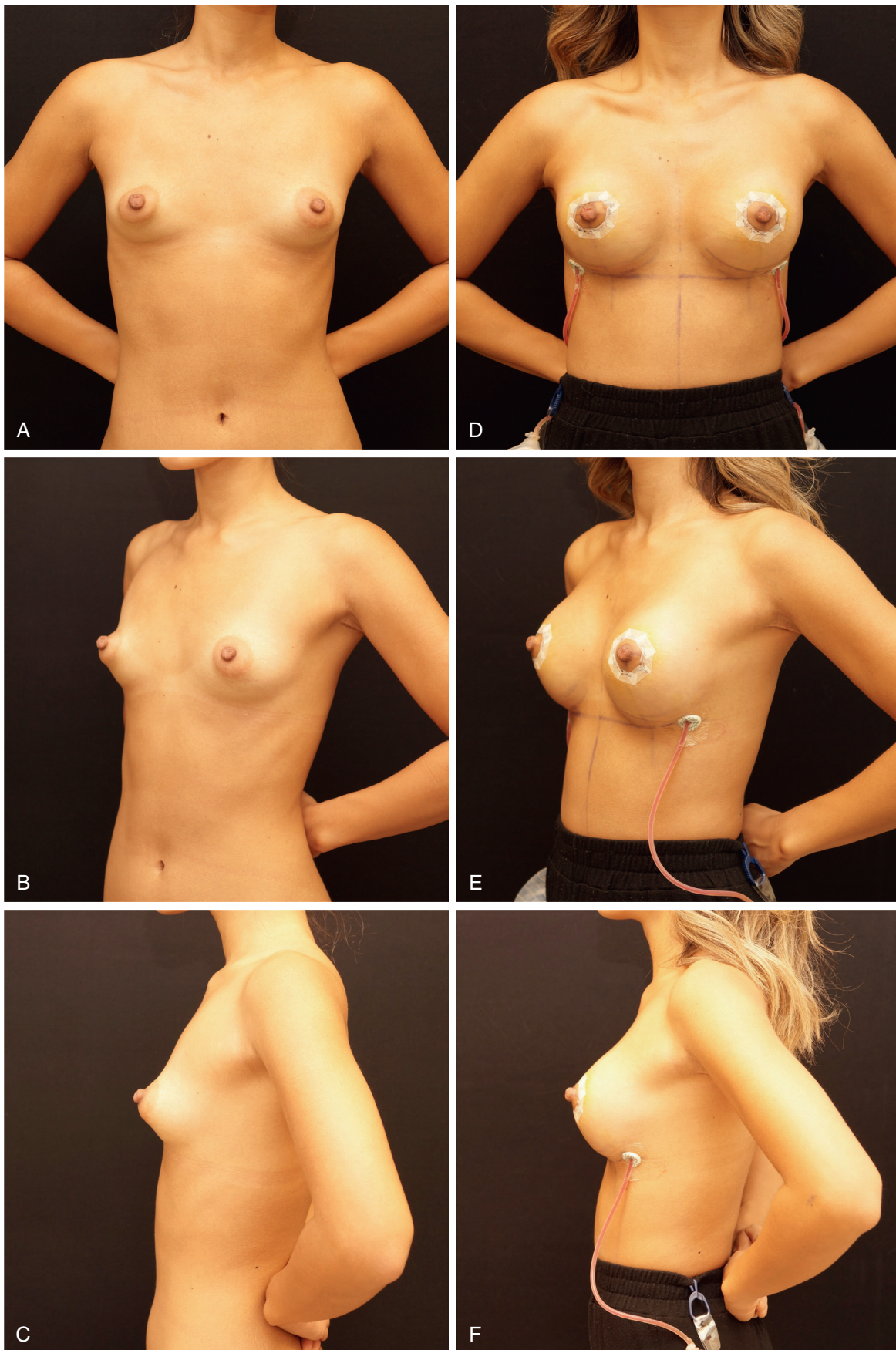
required (Fig. 24.8). Implant sizers are used during this process both to establish ideal breast size and to confirm the effects of the scoring maneuvers on breast shape. The use of a temporary sizer is crucial to establish that an appropriate release has been achieved. If the intraoperative creation of lower pole breast shape and the achievement of appropriate breast size is deemed adequate, a one-stage correction with planned insertion of an implant ensues. Fig. 24.9 demonstrates ideally achievable lower pole shape development and IMF repositioning in one stage intraoperatively. In the event that the maneuvers have not satisfactorily overcome the memory of the pre-existing IMF or if the lower pole shape is deemed inadequate, insertion of a tissue expander is planned.

After infiltration of 0.25% bupivacaine solution into pectoralis muscle and deep musculofascial planes, hemostasis is confirmed and the regions are irrigated with dilute betadine solution and triple antibiotic solution. Dissection planes are drained with a closed suction drain in all cases. One-stage prosthetic augmentation, or first-stage insertion of a tissue expander, is performed with implants placed in a subpectoral (dual plane) position.¹⁵ Natrelle style 410 anatomic, form-stable highly cohesive gel implants or Natrelle Inspira

cohesive gel-filled implants are currently used for all one-stage corrections and for second-stage expander-to-implant exchanges; Natrelle style 133MV tissue expanders are used in all two-stage corrections (Allergan Inc., Irvine, CA). The gland is then reapproximated in layers with absorbable monofilament suture. Tailor-tacking of the areola to the peripheral concentric circumareolar incision line is performed with skin staples, and with the patient placed temporarily in the seated upright position, fine-tuning of the size, shape and positional symmetry of the areolas are marked and ultimately incised and adjusted accordingly. Peripheral dermis is incised to minimize potential pleating, and an interlocking purse-string suture with non-absorbable suture material (CV-3 GoreTex, W.L. Gore & Associates, Inc., Flagstaff, AZ) coapts the concentric incision lines and reduces the areolar surface area and projection. When ptosis correction with the circumareolar mastopexy insufficiently improves breast shape and projection, a vertical mastopexy limb is added. Interrupted and running intradermal absorbable monofilament suture completes the closure. Early recruitment of lower pole fullness and satisfactory repositioning of the IMF at one week postoperative are illustrated in Fig. 24.10. Also note the authors' preferred minimal dressings.



• **Fig. 24.9** (A) Preoperative image of a 29-year-old woman with bilateral type III tuberous breast deformity. (B) Intraoperative image demonstrating temporarily tailor-tacked areolar coaptation and the degree of lower pole shape creation that can be achieved. (C) Thirteen-month postoperative results following circumareolar mastopexy, dual plane placement of Allergan style 10-210 (210 cc) smooth round gel implants. (Reproduced, in part, from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg*. 2015;135(1):73–86, Figure 4.)



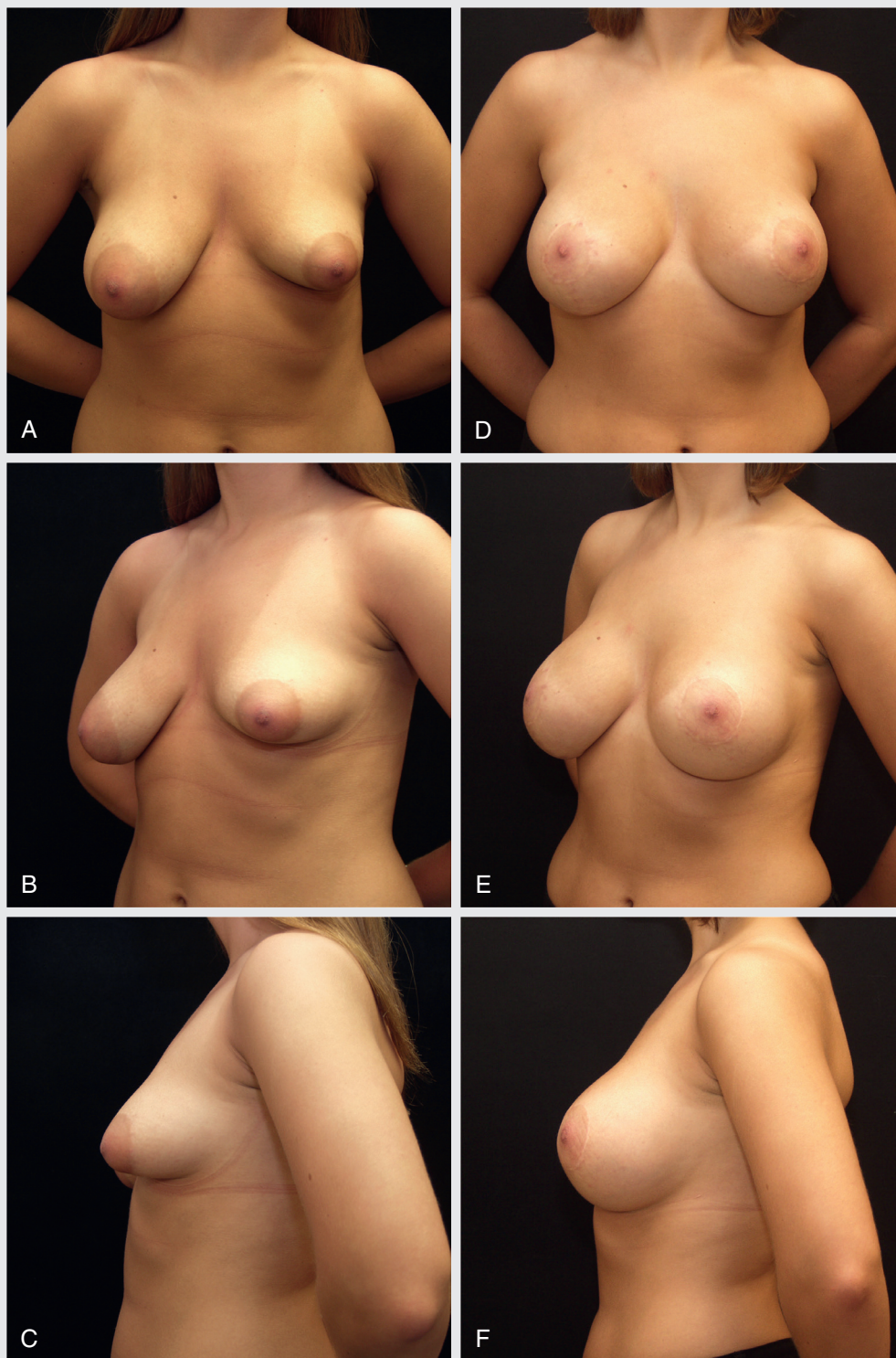
• **Fig. 24.10** (A–C) Preoperative images of a 30-year-old woman with type II tuberous breast deformity, and (D–F) one-week postoperative results following circumareolar mastopexy, and dual plane placement of Allergan style 410 anatomic highly cohesive form-stable silicone gel implants, MM-245 (245 cc). Note the early-stage development of lower pole shape, as well as the minimal periareolar Steri-Strip dressings with Biopatch and bio-occlusive dressings at the drain sites.

Case Examples

CASE 24.1

This 20-year-old woman with right type I tuberous breast deformity and left type II tuberous breast deformity was treated in one stage with a right circumareolar and vertical mastopexy, a left circumareolar mastopexy, and dual plane placement of

Allergan style 10-270 (270 cc) (right breast) and 15-371 (371 cc) (left breast) smooth round implants. [Case 24.1.1](#) shows preoperative images (A–C) and 12-month postoperative images (D–F).



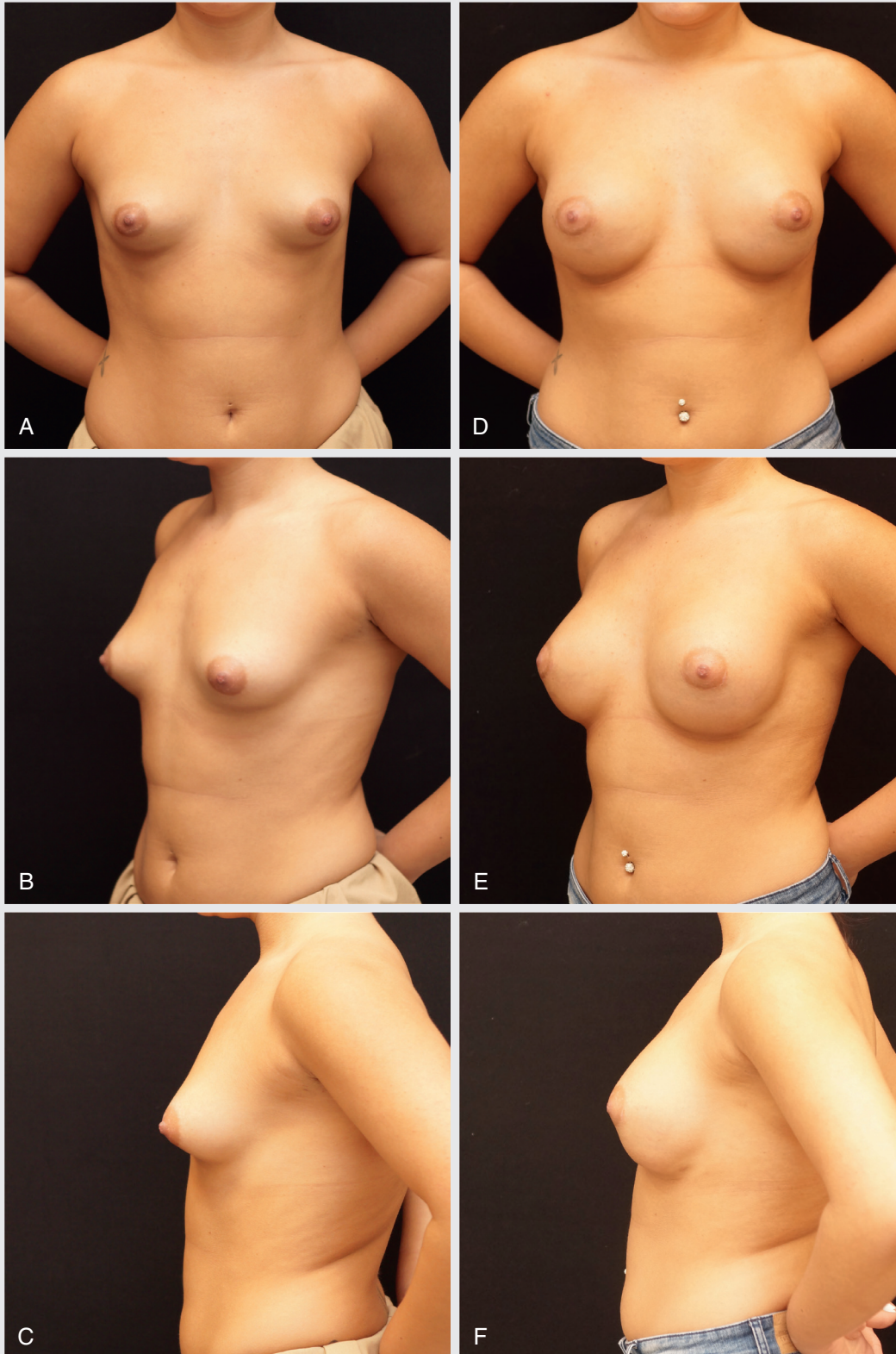
• Case 24.1.1

(Case 24.1.1 reproduced from Kolker AR, Collins MS. Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg*. 2015;135(1):73–86, Fig. 7.)

CASE 24.2

This 21-year-old woman with bilateral type II tuberous breast deformity was treated in a single stage with bilateral circumareolar mastopexy, with dual plane placement of moderate height, moderate projection Allergan style 410

anatomic highly cohesive gel implants MM-245 (245 cc). [Case 24.2.1](#) shows preoperative images (A–C), and 12-month postoperative images (D–F).

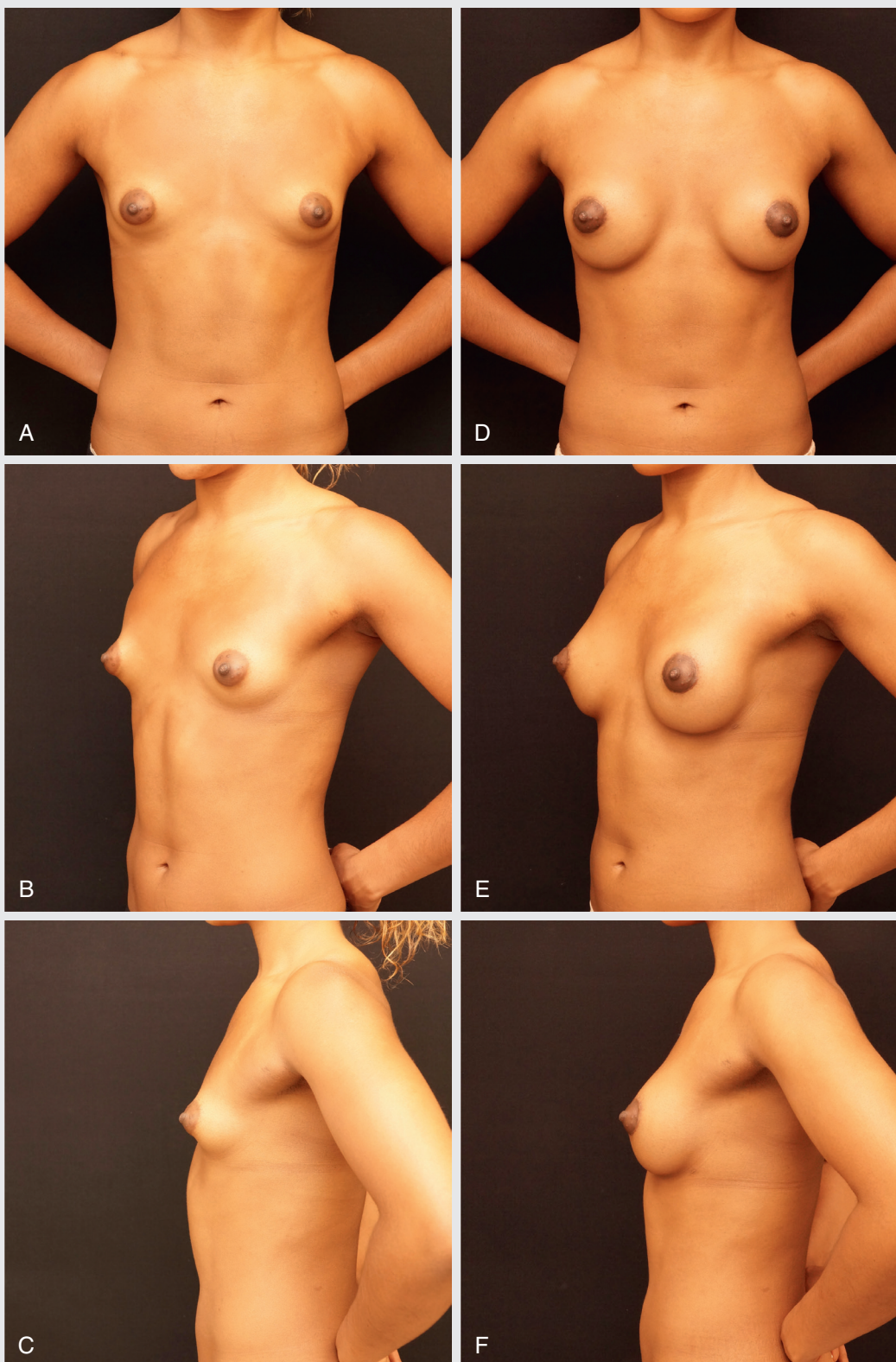


• Case 24.2.1

CASE 24.3

This 31-year-old woman with bilateral type II tuberous breast deformity was treated in a single stage with bilateral circumareolar mastopexy, with dual plane placement of

Allergan Inspira smooth round implants, SRM-210 (210 cc). [Case 24.3.1](#) shows preoperative images (A–C), and 10-month postoperative images (D–F).

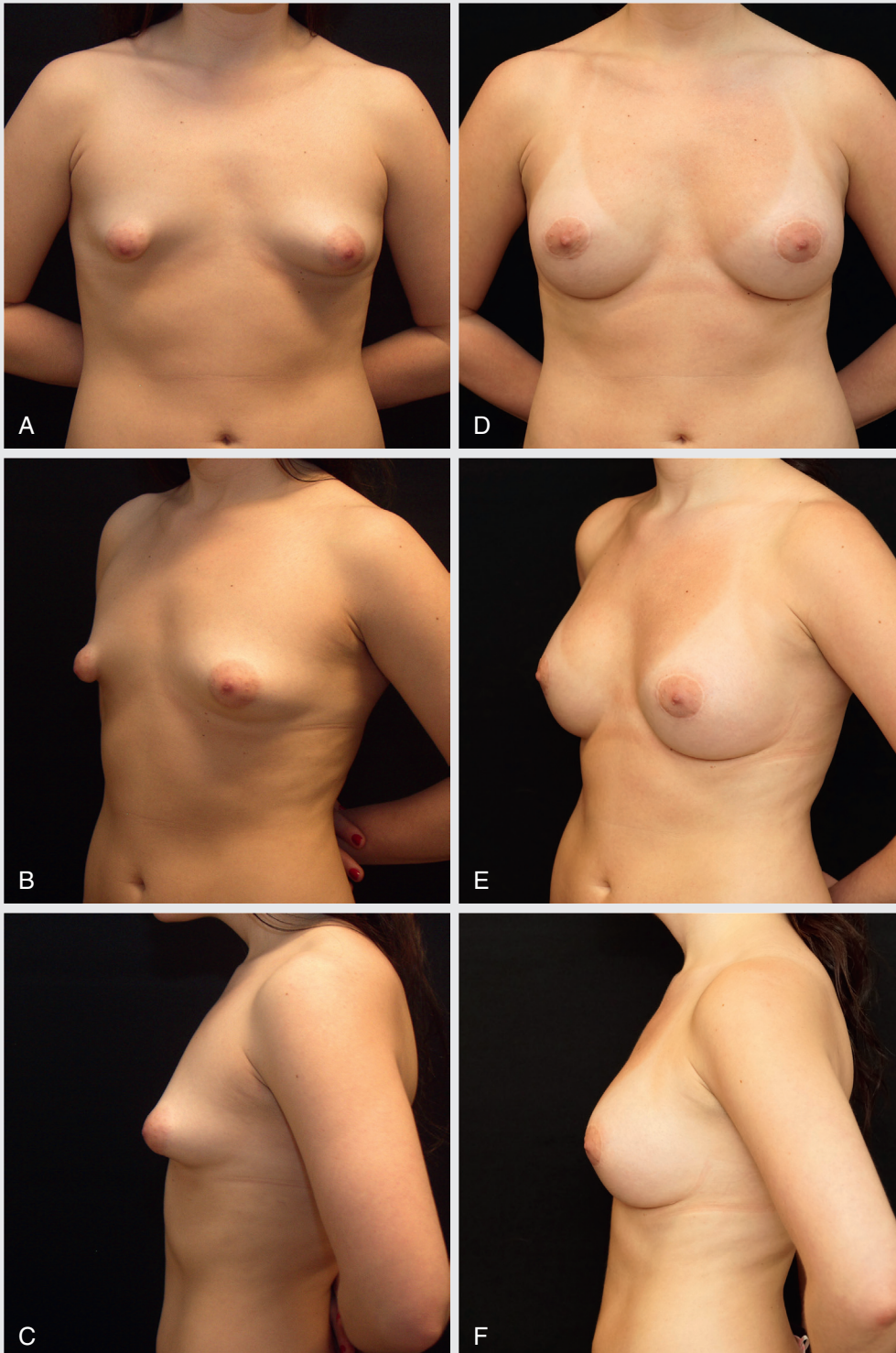


• Case 24.3.1

CASE 24.4

This 27-year-old woman with right type III tuberous breast deformity and left type II tuberous breast deformity was treated in two stages. While a satisfactory result may have been achieved in one stage, the patient desired a full yet natural result that could not be obtained without tissue expansion. Bilateral circumareolar mastopexy was performed, with dual plane placement of Allergan style 133 MV-12300 cc tissue

expanders at the first stage, sequentially filled to 410 cc bilaterally. After 5 months, the tissue expanders were exchanged with Allergan style 15-339 (339 cc) smooth round silicone gel implants. [Case 24.4.1](#) shows preoperative images (A–C), and 16- and 21-month postoperative images (from index procedure and second stage surgery, respectively; D–F).



• **Case 24.4.1**

([Case 24.4.1](#) reproduced from Kolker AR, Collins MS (2015) Tuberous breast deformity: classification and treatment strategy for improving consistency in aesthetic correction. *Plast Reconstr Surg.* 2015;135(1):73–86, Fig. 11.)

Postoperative Care and Expected Outcomes

Tuberous breast correction is always performed as an outpatient, ambulatory procedure. Bupivacaine 0.25% solution is used prior to implant insertion to improve analgesia, to minimize postoperative narcotic requirements, and to hasten first-stage recovery. Dressings include Mastisol or Dermabond and Steri-Strips on the incision lines with light cotton-free gauze and a surgical brassiere. Drain sites are dressed with Biopatch chlorhexidine gluconate protective disks (Ethicon, LLC, Somerville, NJ) and bio-occlusive dressings. Patients are instructed to shower at 36 to 48 hours. Empiric antibiotics (first generation cephalosporin or amoxicillin/clavulanate) are prescribed for one week. Hydrocodone/acetaminophen and ondansetron are taken as needed. Walking during the first week is encouraged. Recommended return to work, school and most normal activities is generally seven days. A more structured, supportive brassiere is worn starting at seven days, at which time light exercise resumes (low impact cardio, core, and lower extremity workouts). Upper body strength training may be resumed at 4–6 weeks. While significant improvements in lower pole shape are often visible immediately, it takes approximately 12 weeks for the resolution of upper pole fullness and rounding of the lower pole to become evident, and up to one year for complete maturation of the results.

Management of Complications

With breast parenchymal hypoplasia, constriction, skin deficiency, areolar herniation, ptosis, and frequent asymmetry, the potential complications and undesirable sequelae of tuberous breast correction include all of those that can be associated with breast augmentation/mastopexy and more. In managing a patient's expectations prior to surgery, the possibility of additional surgery should be made clear. Capsular contracture, implant displacement or malposition, asymmetry, wide scars or areolar enlargement, pseudohermiation of the areola, underexpansion of the lower pole, and persistence of the pre-existing IMF may ensue; when mild, corrective measures may not be required as patient and surgeon satisfaction may still be high relative to the presurgical deformity, however any of these outcomes may necessitate additional surgery.

Capsular contracture can be treated with capsulotomy, capsulectomy, and implant exchange, with consideration given to replacement of a smooth-shelled implant with a textured surface device. Inferior implant malposition may result from over-dissection of the new IMF, or bottoming out of the implant. Judicious definition of the IMF during the index surgery is critical; the use of a textured surface device may also promote IMF position stability. If correction is required, the areolar incision provides ideal access for capsulorrhaphy of the IMF region, coapting the anterior to posterior capsule. Acellular dermal allograft, xenograft or other matrix may play a role if required. Asymmetry of breast size,

shape or position may require future revision. With pre-existing differences in degree of constriction, hypoplasia of skin envelope, hypoplasia and/or hypertrophy, and ptosis, tuberous breast correction becomes a four-dimensional endeavor. Even when relative balance and symmetry is achieved three-dimensionally in the operating room, the fourth dimension, *time*, comes to bear as a result of progressive settling and maturation of mildly or substantially different soft tissue or implant-based maneuvers performed on two subtly or dramatically different breasts. Widening scars or progressive areolar enlargement may result from tuberous breast correction, as this is a “competing vector” operation; expanding and enlarging a hypoplastic constricted skin envelope, while at the same time reducing areolar dimensions can result in a high-tension dynamic in the periareolar region. If scar revision or additional areolar reduction is required, waiting a minimum of one year is recommended to allow for progressive skin and soft tissue settling to minimize any undue tension. Pseudohermiation of the areola may also result, paradoxically, as a consequence of periareolar purse-string control of an enlarged or already herniated areola. This may represent either an incomplete correction of the areolar deformity, or simply the re-establishment of a new, more superficial constricting ring through which breast gland may herniate into an overly pliable areola. Correction can be achieved after ample time is allowed for complete settling to promote maximal periareolar skin compliance. A smaller diameter stamp is made within the slightly protuberant areola, whereupon a re-adjustment of the relationship between the concentric mastopexy circles and replacement of a new purse-string suture are carried out, yielding a more two-dimensional areola.

Perhaps the most onerous of the sequelae of tuberous breast correction are the persistence of a pre-existing IMF and underexpansion of the restricted lower pole. The index procedure is almost entirely “about the lower pole,” and progressing methodically through the maneuvers of the algorithm geared toward releasing any residual intrinsic restriction in this region. After the establishment of a neo-IMF and progressing stepwise through radial scoring as described, there are occasions where the IMF is recalcitrant, and the memory of the fold persists. The surgeon has the choice between selecting an implant, the placement and resulting pressure of which may “iron out” this fold over time, or a tissue expander, which offers much greater control. When confronted with an underexpanded lower pole or residual IMF postoperatively, reoperation with further radial scoring maneuvers and replacement with a form-stable implant may suffice, however the placement of a tissue expander is likely the most reliable solution. Autologous fat grafting may also be of value in select cases, but the authors feel this is often limited, as the thin plane between the implant, capsule, and skin may be mere millimeters.

Secondary Procedures

Tuberous breast deformity, particularly in its milder forms, is often underappreciated and underdiagnosed. When

unrecognized, treating the less obvious variants with more common breast augmentation techniques most often fail to appropriately address the deficiencies and restrictions of the breast lower pole. Moderate and more severe forms of tuberous breast deformity may have been inexpertly corrected. Secondary iatrogenic breast deformities including asymmetry, pre-existing IMF perceptibility, double bubble deformity, implant bottoming-out and malposition, and exacerbated areolar herniation may be present, and can often pose even greater challenges than primary tuberous breast correction. The authors' treatment algorithm remains appropriate in secondary cases as well. Any effort to revise a suboptimal result should be deferred until at least one year from the original procedure. If an IMF incision was used, in most cases it should be disregarded in favor of an areolar approach. If radial scoring fails to adequately reshape the lower pole or overcome the residual IMF memory, a tissue expander is recommended. Autologous fat grafting can also be considered as an aesthetic adjunct in selected cases.

Conclusions

Tuberous breast deformity can present some of the most extraordinary diagnostic and therapeutic challenges for surgeons. The multiple pathological hallmarks including breast base constriction, parenchymal hypoplasia, lower pole skin deficiency, superior malposition of the IMF, areolar herniation, ptosis, and asymmetry can vary widely in their expression. Careful identification and classification of all the pathologic features are required to formulate a treatment plan that, when defined and methodically followed, aids in achieving both safety and consistency in aesthetic results.

PEARLS FOR SUCCESS

- Tuberous breast deformity is a developmental anomaly of uncertain etiology with widely varying presentation.
- It is often underappreciated, underdiagnosed, or undertreated.
- It poses the greatest technical challenge in aesthetic breast surgery, as much from the subtle cases as the severe.
- Anatomic hallmarks include breast base constriction, parenchymal hypoplasia, lower pole skin deficiency, superior malposition of the inframammary fold (IMF), areolar herniation, ptosis, and asymmetry. One, several, or all may be present.
- Careful identification and classification of the pathologic features is crucial for the establishment of a treatment plan.
- The keys to success in tuberous breast correction include: the interruption of the fibrous ring constriction, release and expansion (in one or more stages) of lower pole deficiency, establishment of an appropriately positioned IMF, overcoming pre-existing IMF memory, augmenting the deficient lower pole for both volume and shape maintenance, reduction of areolar herniation, balancing areolar dimensions, correcting ptosis, and correcting asymmetry.
- Adherence to a methodical treatment strategy can aid in maximizing both safety and consistency in aesthetic correction.

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